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ABSTRACT

Several investigations have shown the potential of using remotely sensed data in hydrologic modeling. One of the most promising is in the estimation of the land cover in the computation of the Soil Conservation Service Runoff Curve Number. Each of these studies have shown these data to be cost-effective.

This report describes a computer based procedure for estimating watershed Curve Numbers using remotely sensed data. It is a linkage of some previously developed package programs and new procedures that have been streamlined for this particular application. Landsat data are emphasized, however, other types of data could be used. Examples are presented on each aspect.

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INTRODUCTION

Recent research has indicated that Soil Conservation Service (SCS) runoff Curve Numbers (CN) can be accurately estimated using Landsat imagery (Bondelid, et al., 1980; Ragan and Jackson, 1980; Slack and Welch, 1979). The estimation of CN's using Landsat are both time and cost effective because the Landsat data are in machine readable form. Therefore, digital computers can be used for many of the required computations. An efficient CN estimation procedure has been developed in the course of a study of three watersheds in southeastern Pennsylvania (Bondelid, et al, 1980). The procedure is designed to meet four principle criteria: (1) the computations should be compatable for computer solution; (2) the procedure should be straightforward and not require a high level of expertise in either remote sensing or computer programming; (3) the procedure should be versatile so that it can be modified and expanded for use in a variety of situations; and, (4) the procedure should be accessible to SCS hydrologists and other scientists and not require special equipment that is not normally available to them. The objective of this report is to present an efficient procedure that satisfies these four criteria.

The procedure has been tested and is fully operational on the United States Department of Agriculture (USDA) IBM 370 computer system operated by the Washington Computer Center (WCC). The Landsat analyses are performed using the Office of Remote Sensing for Earth Resources (ORSER) of Pennsylvania State University computer software package described by Borden, et al (1975). The CN analyses are performed using a computer program, called CNPROG, that is designed for performing efficient CN evaluations using a digital land cover data base, such as can be produced using Landsat. A full description of the

capabilities, input requirements, and output products of CNPROG is included in this report. Examples of all of the types of ORSER and CNPROG runs are also included. The ORSER users manual (Borden, et al, 1975) contains full descriptions of these procedures.

COMPUTERIZED CURVE NUMBER ESTIMATION

Runoff curve numbers are a function of land cover, soil type, and antecedent soil moisture conditions. Soil types are classified into four hydrologic soil groups according to the infiltration capacity of the soil. The four soil groups are labeled A, B, C, and D; group A soils have the highest infiltration rates while group D soils have the lowest rates.

Soils data are generally spatial in nature, in that a particular soil type will occupy a particular region or regions within the watershed under study. Also, for hydrologic modeling purposes, the CN's must be estimated for each individual watershed. The three spatial parameters of land cover, soil groups, and subwatersheds must be coordinated in producing the weighted average CN for a watershed.

The basic function of CNPROG is to transform spatial soils and subwatersheds boundaries to a digital data base that has a point by point correspondence to the digital land cover data file. The program can then evaluate runoff CN's on a point by point basis and compute the CN's on a subwatershed basis. The program also has the capability of generating subwatershed and soils maps. These maps are useful for checking the accuracy of the input soil and subarea boundary point data.

Figure 1 presents a flow chart of the computerized CN estimation procedure. The three basic steps in the procedure are: (1) development of watershed data files; (2) development of Landsat land cover data files; and, (3) integration of watershed and land cover data to produce the CN estimates.

The basic data requirements for performing the procedure are:

- Landsat computer tapes and imagery of the region
- United States Geological Survey (USGS) maps of the region at both 1:25,000 and 1:1,000,000 scales
- A map of the watershed and subwatershed boundaries at a 1:24,000 scale
- Either a map of the hydrologic soils groups or a table that gives the percent of each soil group for each subwatershed

The remaining sections of this report will essentially follow the sequence shown in the flow chart of Fig. 1. The general procedure can be executed on any computer system that can support a Landsat analysis package and CNPROG. The examples in this report will use the ORSER package and CNPROG on the USDA IBM 370.

The left hand side of Fig. 1 shows the general sequence of steps necessary for developing the subwatershed boundary point data and the soil group data. CNPROG is used to transform boundary point data to a digital data base that is compatible with the Landsat land cover data base. Subwatershed and soil group maps can be produced by CNPROG for checking the accuracy of the boundary point data. Finally, CNPROG is used for integrating the subwatershed, soil group, and land cover data bases to compute CN's.

The remaining sections of this report present the basic principles and procedures necessary for performing the sequences shown in Fig. 1 including Landsat analysis procedure with examples of each type of computer run that will be needed, the steps necessary for generating the subwatershed and soil group input data files, a users manual for CNPROG, how to process the subwatershed and soil group input data files and integrate these data files with the land cover files for computing CN's, and, finally, a complete example CN analysis using CNPROG.

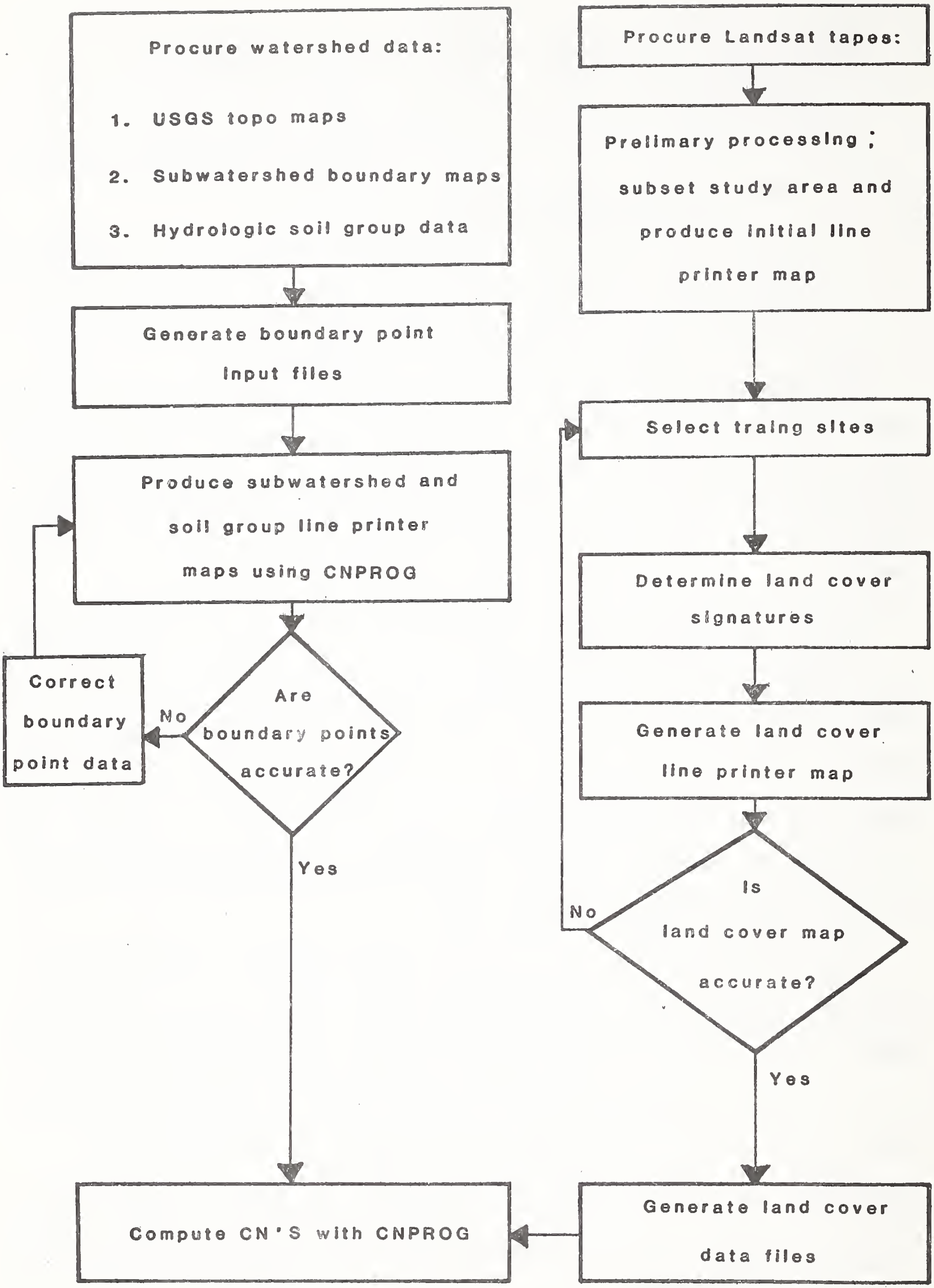

FIGURE 1. FLOW CHART OF LANDSAT CURVE NUMBER ANALYSIS PROCEDURE

OVERVIEW OF LANDSAT IN ANALYSIS

As shown in Figure 1, there are basically two parallel processes necessary for using Landsat to estimate CNs. The ORSER computer package is used for the Landsat processing and CNPROG is used for the watershed data processing. CNPROG is also used for the integration of the Landsat and watershed data files.

Computer Requirements

Because the procedure is oriented primarily to the needs of SCS hydrologists, the example input files include the necessary IBM Job Control Language (JCL) statements for use on the USDA IBM 370 computer system. An understanding of IBM JCL is not necessary to understand the Landsat CN analysis procedure. A simple rule for those users unfamiliar with IBM JCL is that all lines that begin with a slash are JCL statements; all other lines are actual input data. A programming consultant may need to be contacted if the user is unfamiliar with IBM JCL.

The Landsat CN analysis procedure is designed to be easily adapted to computer systems other than IBM. The basic requirements are that a Landsat analysis package that produces line printer maps and CNPROG be accessible to the user. CNPROG is written in FORTRAN IV so that it is essentially machine independent. The Landsat analysis package will require minimal modifications; these modifications are explained in the CNPROG User's Guide, which is contained in this manual.

Using the ORSER Package

The ORSER program package is a comprehensive set of programs for analysis of digital remote sensing data. Although it is not necessary, it is recommended that the user obtain access to a copy of the ORSER User's Manual for the Landsat analysis.

All of the ORSER computer runs used in the CN analysis are straightforward and require relatively few input cards to perform the Landsat phase of the procedure. The example input files contained in this manual can be used with only the obvious changes in various numerical values and data file names.

The ORSER input cards consist of English language commands and, if necessary, input data values. For instance, the command CORRECT specifies that the Landsat data will be geometrically corrected during program execution. Generally, only the commands contained in the example input files will be necessary for the Landsat analysis

Using CNPROG

CNPROG is a user oriented package that can be used in either an interactive or a batch mode. CNPROG allows the user to specify the logical unit numbers and formats of the required data files during execution. The data files that are required for a particular execution depend upon the CNPROG options used. The data file requirements will be discussed in subsequent sections.

The basic input sequence consists of command words that are followed by input data. For instance, the command INFILE is used to specify an input data file unit. After the command INFILE is typed, the program prompts the user with a message stating that the input file unit should be entered in columns 1-2. The value entered is then read and checked for obvious input errors. If the input value is either nonnumerical or less than or equal to zero, a message is printed that indicates an error. Then the program again prompts the user for the input file unit number. If the input value is accepted, then the program will prompt the user for a new command. This process is continued until all desired processing is completed.

In an interactive mode, the program prompts and error messages guide the user through the program execution. Also, an incorrect data entry will generally not cause an abortion of the entire program execution. In a batch mode, the prompts and error messages are suppressed. If an input error is detected, then program execution continues until actual data file processing starts. At that point, if errors have been detected, error messages are printed and data file processing is not performed.

CNPROG Processors

CNPROG consists of basically three processor options. The first processor is the file generator and is invoked by the command FILEGEN. The file generator option is used for producing soils and subarea files that have a point by point correspondence to the land cover data files. These files can be either saved for use in subsequent executions or used in the same execution. The second processor is the map generator that is invoked by the command MAPGEN. This processor is used for producing subarea and soils maps from files produced by FILEGEN. The third processor is the CN calculator, which is invoked by the command CNCALC. This processor utilizes the subarea and soils files generated by FILEGEN and the land cover data files generated by the land cover classifier. The CNCALC processor computes areas, CN's, land cover percentages, and soil type percentages for each subarea and for the watershed as a whole.

All of the processors can be used in one execution or, for instance, only the FILEGEN processor can be used in one program execution. The generated files in the first execution can be used in subsequent executions in which the MAPGEN and/or CNCALC processors are used.

FILEGEN Processor

The file generation processor (FILEGEN) converts the subarea and soils boundary point data to files that have a point by point correspondence to the land cover data files produced by the land cover classifier. Sometimes the map image for an area being studied is wider than the line printer paper. In these cases, the map image consists of two or more map strips, which can be placed side by side to produce the entire map. The land cover map image file thus is either sequenced by these map strips or there can be a separate file for each map strip. The files generated by FILEGEN must also be sequenced by map strips corresponding to the land cover map strips.

The map images produced by land classifiers can be thought of as a coordinate system in which each print line, referred to as a scan line, is numbered sequentially from top to bottom. Each column, referred to as an element, is numbered sequentially from left to right. Each pixel on the map is thus defined by scan line and element values, which are produced by the land cover classifier. Each land cover type is assigned an alphameric character so each scan line consists of a string of characters in which each character specifies the land cover for a pixel.

The land cover data can be in a sequential file that is (n x m) records long, in which n is the number of scan lines and m is the number of map strips. The first n records contain the land cover data for the first map strip, the next n records are for the second map strip, etc. If each map

strip is on a separate file, then there are m files with each file being n records long. The number of elements in each record is equal to the width of the particular map strip.

The files produced by FILEGEN are analogous to the land cover map files; they are organized sequentially by scan line and map strips. The user generally does not need to understand this file structure because CNPROG internally handles the file reading and writing.

MAPGEN Processor

The MAPGEN processor generates line printer map images from the FILEGEN scan line files. These maps use the same line and element coordinate system that is used for the land cover file. The maps are useful for checking the accuracy of the subarea and soils boundary data. CNPROG automatically assigns a unique map symbol to each subarea.

CNCALC Processor

The CN calculations are performed by the CNCALC processor. CNCALC uses the land cover file and FILEGEN scan line files for computing the CN's. The CN's are calculated for each point for each subarea and takes a weighted average for computing the overall CN for each subarea.

The CN for a particular pixel is based on an input CN table. The table contains the CN values for the four hydrologic soil groups for each alphameric land use symbol. If the land cover for a point is unclassified (i.e., the symbol for that pixel is a blank space), then the pixel is not included in the CN computation. The pixel is included in the determination of total area.

LANDSAT LAND COVER CLASSIFICATION

The basic objective of the Landsat analysis is to produce a land cover map that can be used for estimating CN's. The land cover classifications must be sufficiently general to be identifiable with Landsat while also containing enough detail to adequately define the CN values. Table 1 contains an example of a set of Landsat land cover categories and the corresponding CN values for the four hydrologic soil groups. This table was used successfully in a study in southeastern Pennsylvania (Bondelid, et al., 1980). Table 1 is presented for illustrative purposes only; the land cover classifications

TABLE 1. Example Landsat Curve Number Table

	Soil Group			
Land Cover	A	B	C	D
Woods	25	55	70	77
Agriculture	64	75	83	87
Residential	60	74	83	87
Highly Impervious	90	93	94	95
Water	98	98	98	98

used in a particular region may vary depending on the dominate land cover types in the region.

An understanding of the basic properties of Landsat data is essential for understanding the Landsat land cover classification procedure. The Landsat data is available in two forms: (1) Landsat imagery, in which the data are presented as color or black and white pictures at a scale of 1:1,000,000; or, (2) the Landsat digital data, which are contained on computer compatible magnetic tapes.

Landsat Data

The basic Landsat classification procedure is a four step process: procuring the Landsat data, preliminary data processing, determining the land cover classifications, and producing a land cover map. The final land cover map is produced as a line printer map and also in a machine-readable form for computing CN's using CNPROG.

The Landsat satellites circle the globe in a circular, near-polar, sun-synchronous orbit so that the same point on the Earth's surface is viewed every 18 days at the same time of day. The sensing system that is used for the CN analyses is the multispectral scanner (MSS), which acquires images in four spectral bands of the electromagnetic spectrum. These four bands are:

1. Band 4, the green band, between 0.5 and 0.6 micrometers (m). This band emphasizes sediment-laden and shallow waters.
2. Band 5, the red band, between 0.6 and 0.7 m. This band emphasizes man-made features such as urban and rural settlements.
3. Band b, a near infrared (IR) band, between 0.7 and 0.8 m. This band emphasizes vegetation and landforms.
4. Band 7, another near IR band, between 0.8 and 1.1 m. This band also emphasizes vegetation and landforms, and provides the best haze penetration.

The Landsat data are separated into sections called "scenes". Each scene is approximately 185 km. wide by 185 km. long. The Landsat computer compatible tapes (CCT) are stripped into four separate files, with each strip being 46.25 km wide by 185 km. long.

Each digital picture element (pixel) is 57 m wide by 79 m long. The Landsat CCT's contain the spectral response values in the four bands for each

pixel in the scene. The components of Landsat scenes are illustrated in Figure 2. The rows of pixels are referred to as "scan lines" and the columns are referred to as elements. The lines are numbered consecutively from north to south and the elements are numbered from west to east.

Landsat classification of land cover is based on the premise that each land cover type has a specific range of spectral responses in one or more channels. For instance, because water has very low IR reflectance, all pixels with low reflectance values in bands 6 or 7 can be classified as water. The appropriate spectral response ranges must be determined for each scene being analyzed because of variables such as sun angle and atmospheric haze.

Information on ordering Landsat data can be obtained from the Earth Resources Observation Systems (EROS) Program center administered by the USGS. A packet of ordering information can be obtained from:

Customer Relations
EROS Data Center
Sioux Falls, SD 57198
(605) 594-6511 ext. 151

<u>Preliminary Processing</u>

After the Landsat data have been obtained, some preliminary processing is necessary. The preliminary processing includes: (1) subsetting the study area from the full Landsat scene; (2) geometrically correcting, rotating, and rescaling the data; and, (3) producing a "brightness" map of the study area. The ORSER programs that are used for the preliminary processing are SPAN, SUBGM, and NMAP.

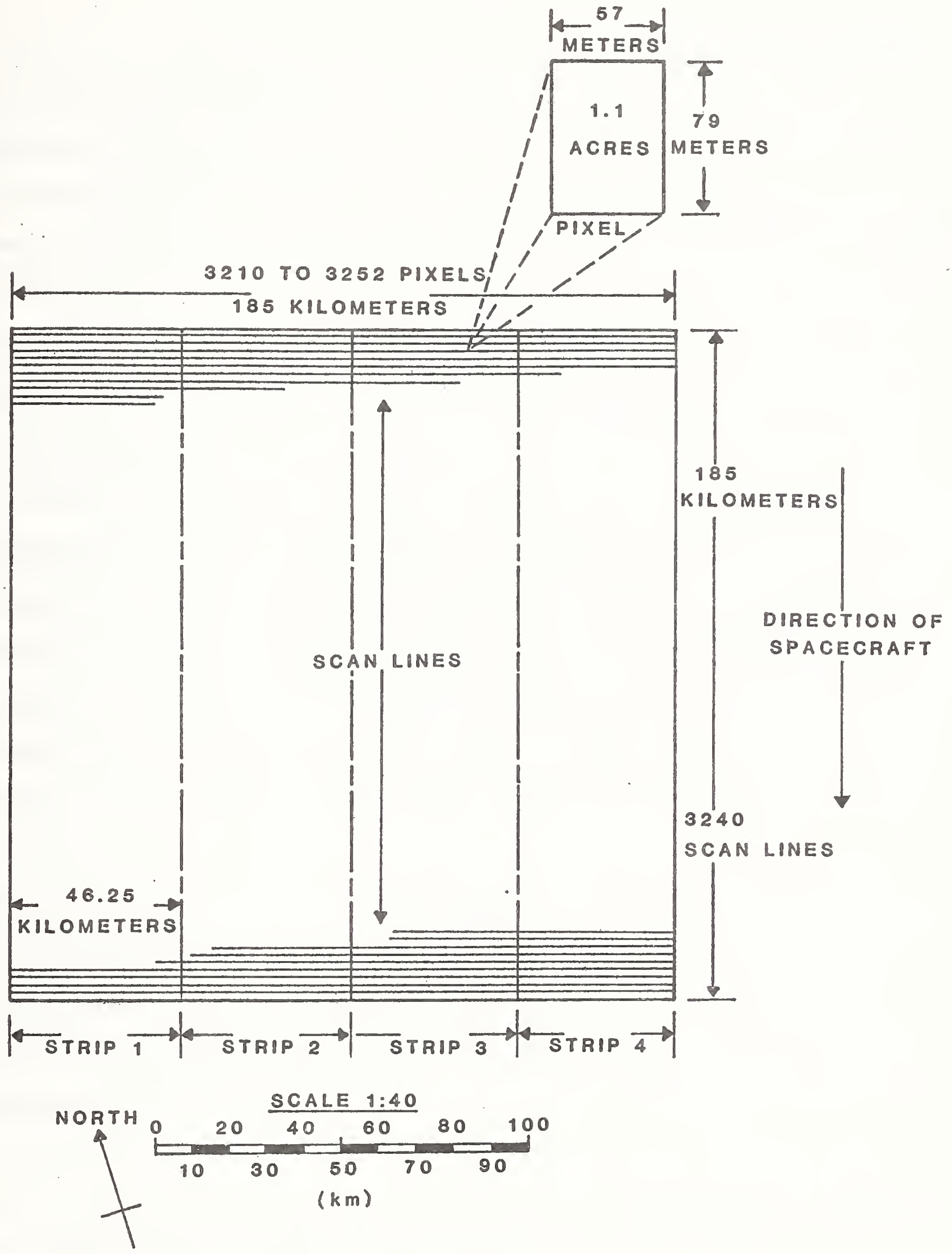

FIGURE 2. LANDSAT SCENE COMPONENTS

Subsetting the Study Area

The area under study for CN analysis will generally be much smaller than the full Landsat scene. For efficient processing, a subset tape that contains data for only the general study area should be created. The Landsat data can also be geometrically corrected, rescaled to 1:24,000, and rotated to true north during the subsetting procedure.

The area to subset is defined by a rectangular block in which the line and element coordinates of the block are input to the appropriate ORSER program. The coordinates of the block can be determined by overlaying a transparent 1:1,000,000 scale map over the Landsat imagery. The rectangular block for the study area can then be outlined on the Landsat image. The coordinates (line and element values) of the block can be easily determined because the number of lines and elements in the entire scene is known. For instance, if the left side of the block is located 35% of the total width away from the left edge of the scene, then the approximate element value of the left side of the block is 0.35 times the total width in pixels (approximately 3,230), which is equal to 1130.

If the block to be subset overlaps the border between two adjacent strips, then a temporary subset tape must be created using the ORSER program SPAN. SPAN will produce a single ORSER subset tape using the two Landsat files for the adjacent strip. This temporary tape is then used in generating the final subset tape. If the block is entirely on one strip, then SPAN does not need to be run.

Correcting and Rescaling

The final subset tape can be produced using the ORSER program SUBGM. This program can subset, geometrically correct, rotate, and rescale the data. The data must be geometrically corrected because the Landsat image is skewed due to the rotation of the Earth. The data must also be rotated to the true north

because the Landsat path is not exactly north-south. The data must also be rescaled so that the line printer maps will be at a scale of 1:24,000.

Producing a "Brightness" Map

After the subset tape has been generated, a map that shows the overall patterns of "light" and "dark" reflecting areas should be produced. Major landforms such as mountain ranges and water bodies will appear as dark areas on the map. These landforms can then be matched up with the 1:24,000 USGS topo maps to get accurate alignment betwen the ORSER map and the topo maps.

Example Input Files

Figure 3 shows an example input file for running the SPAN program. Fortran units 8 and 9 contain the two strips to be spanned and unit 10 is for the new tape which contains the spanned block. The "SPAN" input card specifies that the block written to unit 10 will contain lines 1030 to 1430 and elements 1580 to 2025. The "CHANNELS" card specifies that all four channels, that is, all four Landsat bands, will be included on the new tape. The "END" card specifies the end of input data.

Figure 4 shows an example SUBGM input file. The new tape produced by the example run of Figure 3 is used as the input tape. The "BLOCK" card specifies that a block containing lines 1030 to 1430 and elements 1580 to 2025 will be processed. The "CORRECT", "ROTATE", "CUBIC", and "ALLOW" cards specify that the new tape will contain geometrically corrected, rotated, and rescaled Landsat data.

Figure 5 shows an example NMAP run using the tape created by running Figure 4. Note that units 6 and 9 are used for line printer output. Each unit prints one map strip; no more than two map strips can be printed in a given run of NMAP.

```
//SEANHTB1 JOB (**********,RJ029),'BONDELID',MSGLEVEL=(1,1),
//   CLASS=B,TIME=(,20),PRTY=2
/*ROUTE  PRINT RMT29
//JOBLIB DD DSN=SEANH02.DRSER2,DISP=SHR
//STEP1 EXEC PGM=SPAN,REGION=200K
//FT06F001 DD SYSOUT=A
//FT08F001 DD UNIT=TAPE9,VOL=SER=A12345,DSN=SEANH02.TAPE1.DATA,
//    DISP=(OLD,KEEP),LABEL=(2,SL,,IN)
//FT09F001 DD UNIT=TAPE9,VOL=SER=B12345,DSN=SEANH02.TAPE2.DATA,
//    LABEL=(1,SL,,IN),DISP=(OLD,KEEP)
//FT10F001 DD UNIT=TAPE9,DISP=(NEW,KEEP,DELETE),DSN=SEANH02.TAPE3.DATA
//    DCB=(RECFM=VBS,LRECL=3696,BLKSIZE=3700),LABEL=(1,SL)
//FT05F001 DD *
SPAN      1030 1430 1580 2025    1    1
CHANNELS   1   2   3   4
END
/*
```

FIGURE 3.   EXAMPLE SPAN INPUT FILE

```
//SEANHTB1 JOB (**********,RJ029),'BONDELID',MSGLEVEL=(1,1),
//. CLASS=N,TIME=10,PRTY=1
/*ROUTE  PRINT RMT29
//JOBLIB DD DSN=SEANH02.DRSER2,DISP=SHR
//STEP1 EXEC PGM=SUBGM,REGION=200K
//FT06F001 DD SYSOUT=A
//FT08F001 DD UNIT=TAPE9,VOL=SER=C12345,DSN=SEANH02.TAPE3.DATA,
//    DISP=(OLD,KEEP),LABEL=(1,SL,,IN)
//FT09F001 DD UNIT=TAPE9,DISP=(NEW,KEEP,DELETE),DSN=SEANH02.TAPE4.DATA,
//    DCB=(RECFM=VBS,LRECL=3696,BLKSIZE=3700),LABEL=(1,SL)
//FT05F001 DD *
BLOCK     1030 1430 1580 2025    1    1
CHANNELS   1   2   3   4
CORRECT
ROTATE
CUBIC
ALLOW
END
/*
```

FIGURE 4. EXAMPLE SUBGM INPUT FILE

```
//SEANHTB1 JOB (**********,RJ029),'BONDELID',MSGLEVEL=(1,1),
//  CLASS=B,TIME=(,20),PRTY=2
/*ROUTE  PRINT RMT29
//JOBLIB DD DSN=SEANH02.DRSER2,DISP=SHR
//STEP1 EXEC PGM=NMAP,REGION=200K
//FT06F001 DD SYSOUT=A
//FT08F001 DD UNIT=TAPE9,VOL=SER=D12345,DSN=SEANH02.TAPE4.DATA,
//    DISP=(OLD,KEEP),LABEL=(1,SL,,IN)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=FA,BLKSIZE=133)
//FT05F001 DD *
BLOCK     1030 1430 1580 1780    1    1
CHANNELS   1   2   3   4
END
/*
```

FIGURE 5. EXAMPLE NMAP INPUT FILE

Land Cover Classification

The spectral responses for the desired land cover classifications must be determined for each Landsat scene being analyzed. The first step is to select "training" sites in which a particular land cover type is dominate. An ideal training site contains only one particular land cover type. The spectral responses of the training sites can be used to generate the ranges of spectral responses applicable to each land cover type. These ranges of spectral responses can then be used to define the land cover classifications for producing a land cover map.

The statistical analysis of the training sites can be performed using the modified ORSER program STATS2. This program is a modified version of the STATS program in which the capability of producing two dimensional histograms of the spectral responses of two channels has been added.

The two dimensional histogram option in STATS2 is invoked by using the 2DHIST control card. 2DHIST is specific to the STATS2 program on the USDA computer and does not exist in the standard ORSER package. The format of the 2DHIST control card is presented in Table 2. An example STATS2 input file is shown in Figure 6. The "SIGN" card specifies that a summary of the spectral signatures for each training area will be output to unit 11. The "HIST" card specifies that one-dimensional histograms for channels 2 and 4 will be produced. Each set of "CATEGORY", "AREA", and "ENDAREA" cards specifies a training site. The "CATEGORY" card specifies the training site index number and name. Each "AREA" card specifies the line and element values of a point on the training site. The "AREA" cards must be input sequentially clockwise or counter-clockwise around the training site polygon. The "ENDAREA" card specifies the end of input polygon points for the training site.

TABLE 2. 2DHIST Control Land Format

Cols.	Description of Contents
1-6	2DHIST
10	Flag for plot size: 1 = 60 characters wide by 40 characters high 2 = 100 characters wide by 50 characters high
11-26	8 two-column integer fields specifying the channels to be used for the histograms. Each histogram requires two fields; the first field specifies the channel to be used for the abscissa and the second field specifies the channel to be used for the ordinate. Up to four different histograms can be specified.
31-50	4 five-column real fields which specify the approximate ranges of values to be displayed. The values are input in the order: minimum x value, maximum x, minimum y, maximum y. If these values are left blank, then the program will determine appropriate values for each histogram.

Specifying the x and y ranges is useful when comparing histograms for different training sites because the scales will be the same for all two dimensional histograms.

```
//SEANHTB6 JOB (4071090299,RJ029),'BONDELID',MSGLEVEL=(1,1),
//   CLASS=B,TIME=(,20)
/*ROUTE  PRINT RMT29
//JOBLIB DD DSN=SEANH02.ORSER2,DISP=SHR
//STEP1 EXEC PGM=STATS2,REGION=300K
//FT06F001 DD SYSOUT=A
//FT09F001 DD UNIT=TAPE9,VOL=SER=028758,DSN=ARS38.PADG1R,
//    LABEL=(1,SL,,IN),DISP=(OLD,KEEP)
//FT11F001 DD UNIT=SYSDA,DSN=SEANH02.TRB.STOUT1.DATA,DISP=(NEW,CATLG),
//    DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120),SPACE=(3120,(25,5),RLSE)
//FT05F001 DD *
SIGN         11
CHANNELS     2   4
HIST         2   4
2DHIST    1 2 4 0 0 0 0 0 0      0.0  59.  0.0  79.
CATEGORY 1  AGRICULTURE
AREA        906 1798
AREA        906 1808
AREA        911 1808
AREA        911 1798
ENDAREA
CATEGORY 2  FOREST 1
AREA        976 1640
AREA        976 1660
AREA        983 1660
AREA        983 1640
ENDAREA
CATEGORY 3  FOREST 2
AREA        942 1860
AREA        942 1878
AREA        952 1878
AREA        952 1860
ENDAREA
CATEGORY 4  URBAN
AREA        872 1731
AREA        872 1755
AREA        880 1755
AREA        880 1731
ENDAREA
CATEGORY 5  RESID. MOSTLY
AREA        890 1730
AREA        890 1738
AREA        895 1738
AREA        895 1730
ENDAREA
CATEGORY 6  MINE TAILINGS POND
AREA        862 1714
AREA        862 1716
AREA        865 1716
AREA        865 1714
ENDAREA
END
```

FIGURE 6.   EXAMPLE STATS2 INPUT FILE

Parallelapiped classification method.

All methods of classifying Landsat data are based on the premise that a particular land cover type has a distinct range of spectral responses. The parallelapiped classification (PPD) method utilizes rectangular "boxes" to specify the ranges of spectral responses for each land cover type. The PPD method is recommended for Landsat CN analyses for four reasons: (1) the method has been used successfully in previous CN studies; (2) the method is easy to understand and use; (3) the number of unclassified pixels can be kept small; and, (4) the method is relatively inexpensive in terms of computer costs.

Frequently, only two bands are necessary to adequately classify Landsat data; one visible band and one IR band. This is because the spectral responses for a particular land cover type are very similar when comparing either the two visible or the two IR bands to each other. For instance, the study in southeastern Pennsylvania used only the data for bands 5 and 7 in performing the PPD classifications. The classification boundaries used in that study are shown in Figure 7. Note that more than one "box" was used for defining each land cover type.

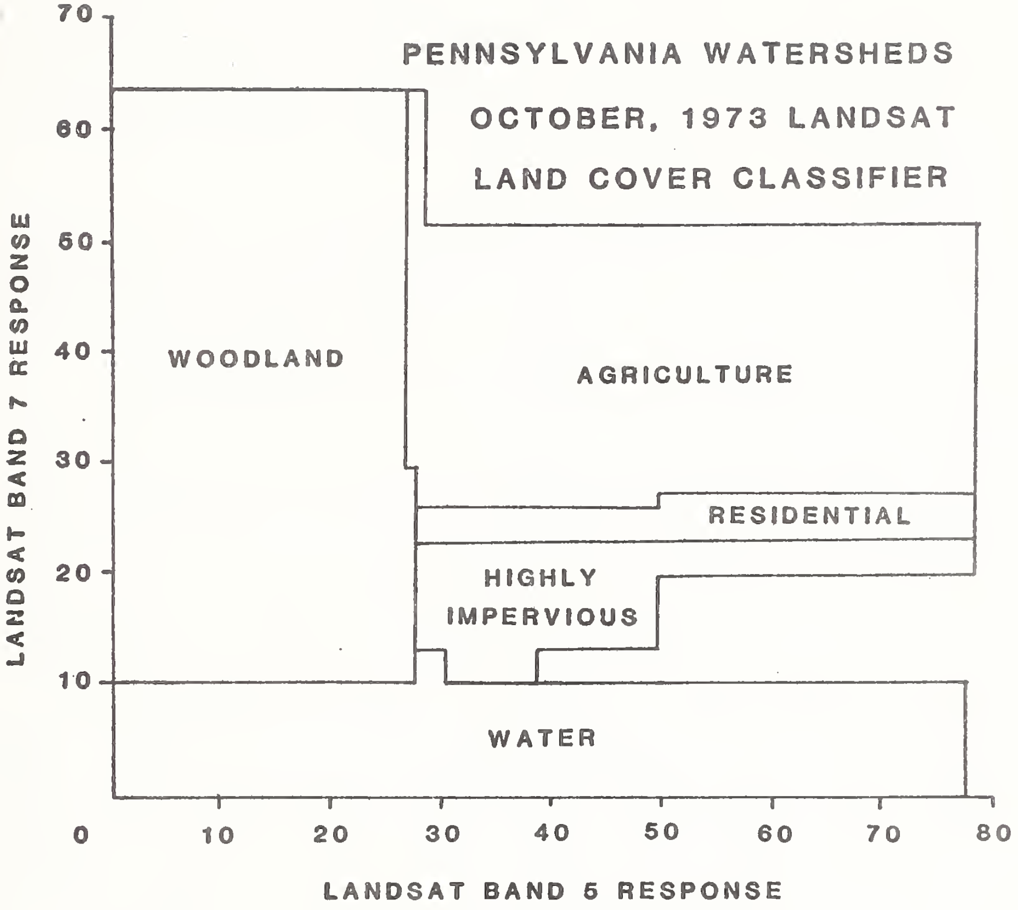

FIGURE 7. PARALLELAPIPED CLASSIFIER FOR THE PENNSYLVANIA WATERSHEDS

The ORSER program PPD produces land cover maps using the parallelapiped method. Each PPD run can produce a line printer map that is up to two sheets wide. If the study area is wider than two sheets, then more than one run of PPD is required.

The two dimensional histograms produced by STATS2 are quite useful in doing a PPD classification. The following example, using data from the study in southeastern Pennsylvania, is presented to illustrate the PPD classification procedure.

Figures 8 through 13 show histograms for selected training sites. The classification boundaries from Figure 2-5 are superimposed on the histograms to illustrate how the PPD limits can be determined using the histograms. Figure 6 shows the STATS2 input file used for producing Figures 7 to 13.

The histograms show the frequency distributions of the spectral response values in selected training areas. The training areas used in the examples are agriculture, forest, urban, residential, and a mine tailings pond. Each histogram represents the spectral distribution for a particular land cover type. The PPD bounds are delineated by drawing rectangular boxes around the clusters of points on the histograms. Note that several of the boxes drawn on the example histograms are larger than the clusters shown. A particular PPD "box" can frequently be enlarged so long as the enlargement does not interfere with the bounds for other land cover types.

The classification process is often iterative, as shown in Figure 1. The land cover map determined from the first STATS2 analysis may not be adequate; that is, there may be regions of unclassified or mis-classified land covers. In such cases, additional training sites should be analyzed and the PPD bounds adjusted until the resulting land cover map is judged adequate.

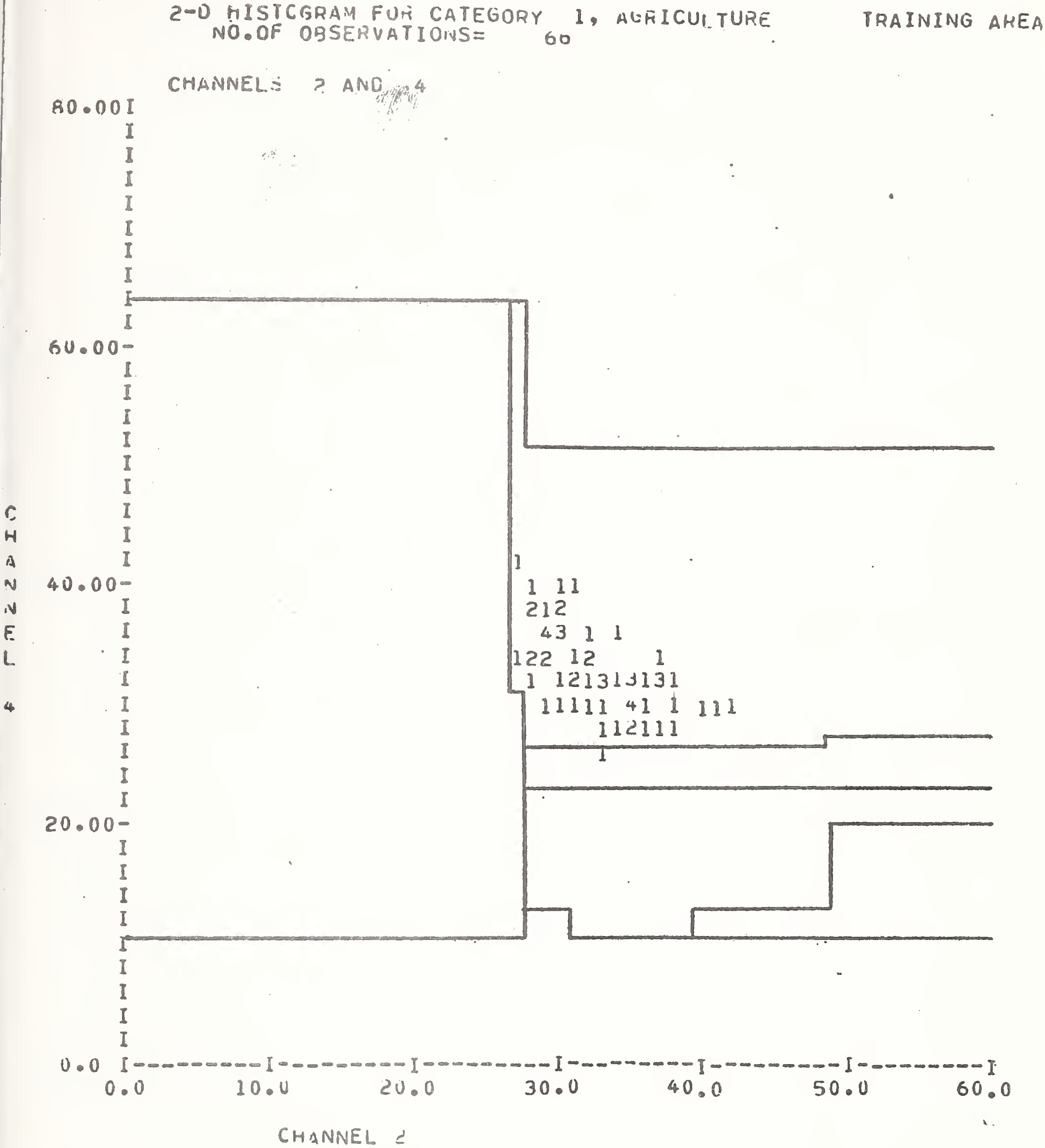

FIGURE 8. EXAMPLE 2-D HISTOGRAM FOR AGRICULTURE

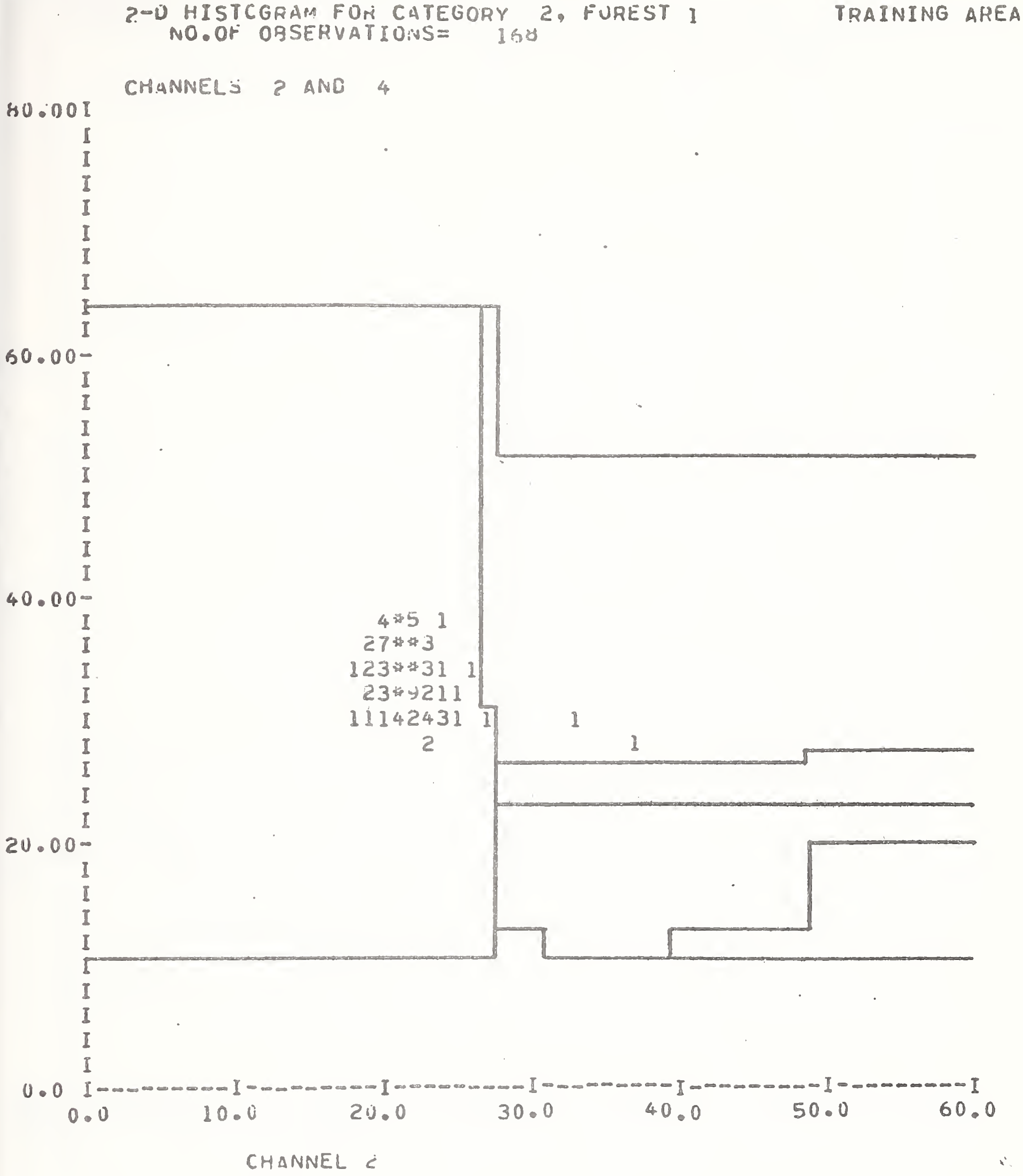

FIGURE 9. EXAMPLE 2-D HISTOGRAM FOR FOREST 1

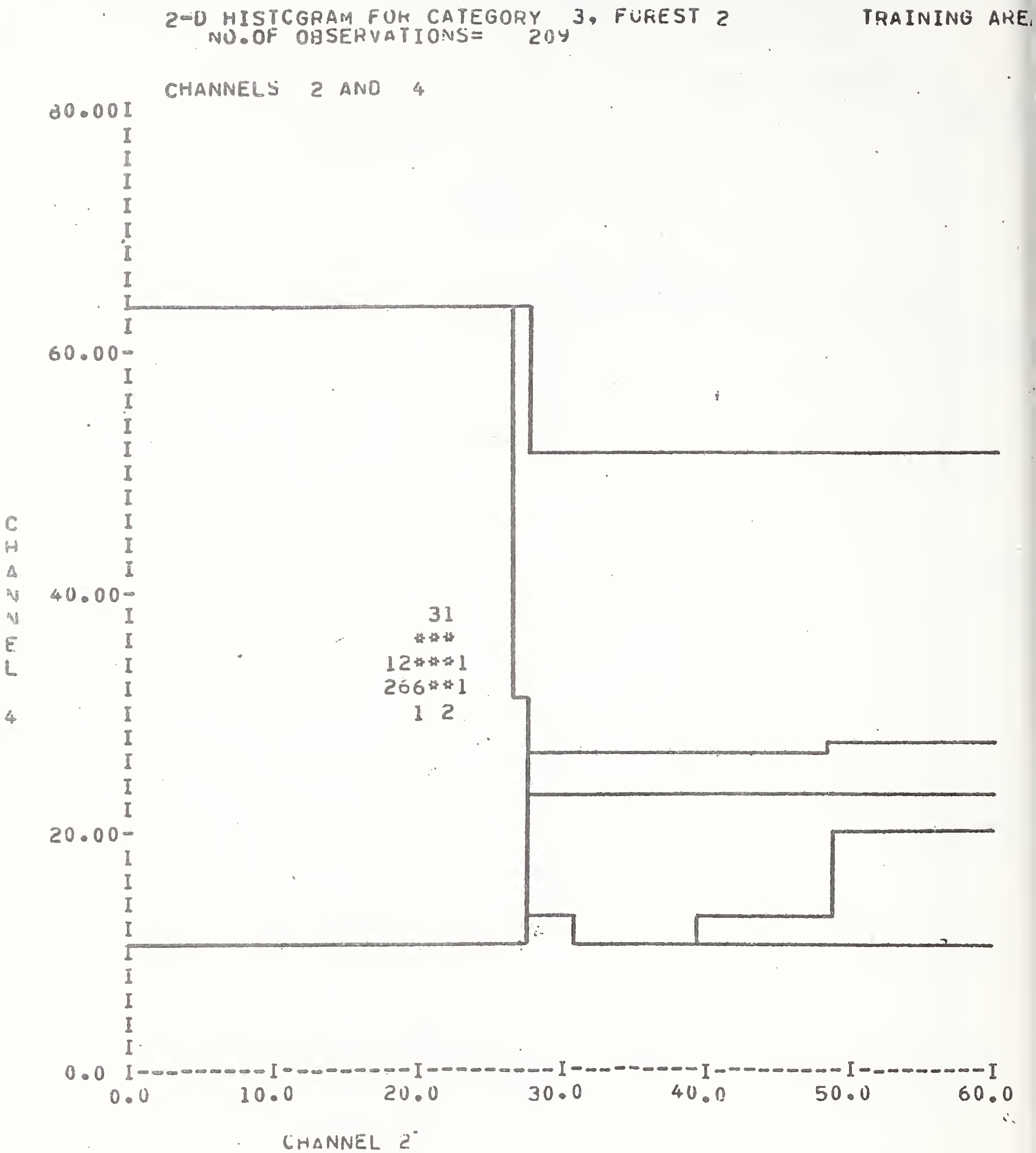

FIGURE 10. EXAMPLE 2-D HISTOGRAM FOR FOREST 2

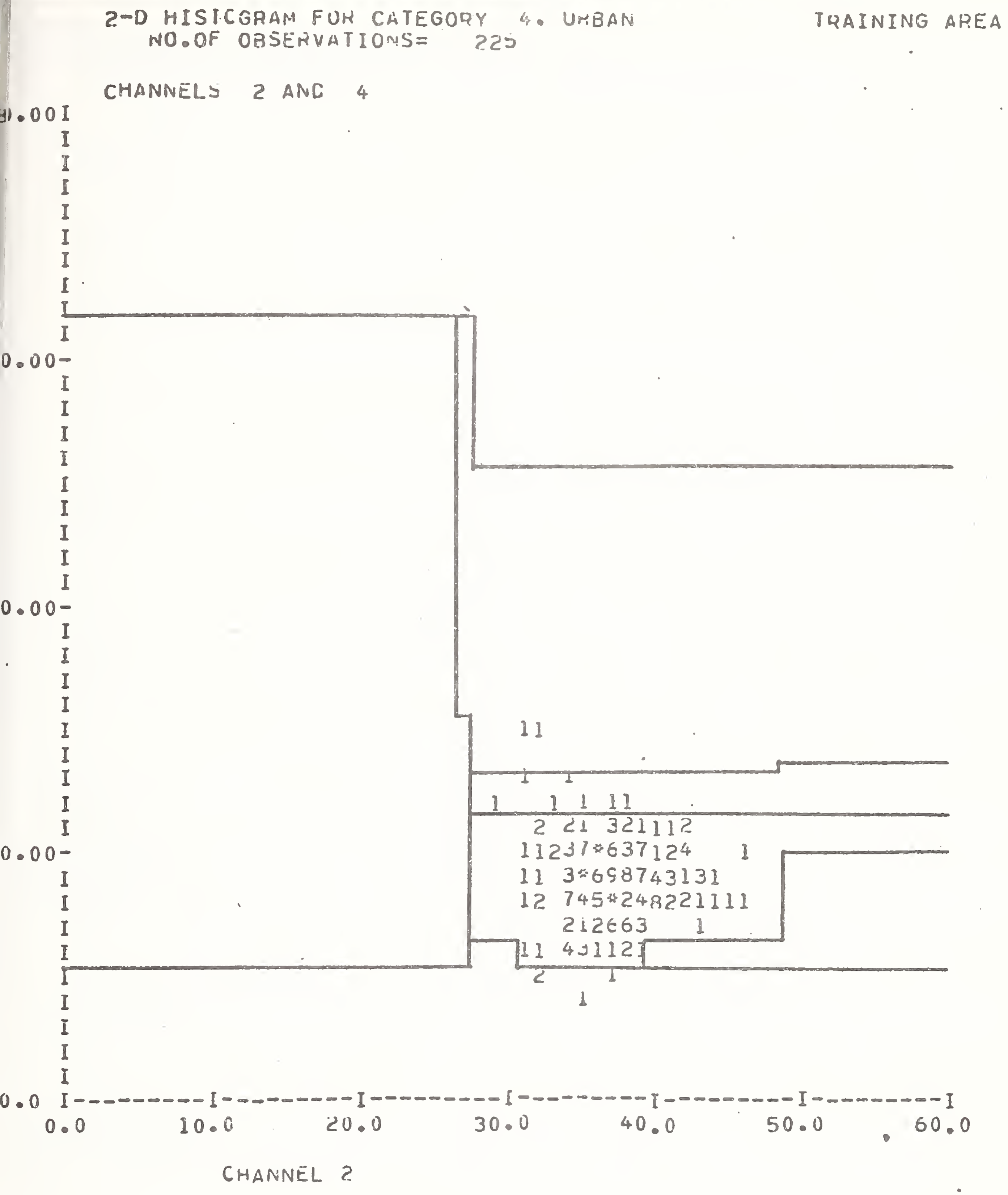

FIGURE 11. EXAMPLE 2-D HISTOGRAM FOR URBAN

2-D HISTOGRAM FOR CATEGORY 5, RESID. MOSTLY TRAINING AREA
NO.OF OBSERVATIONS= 54

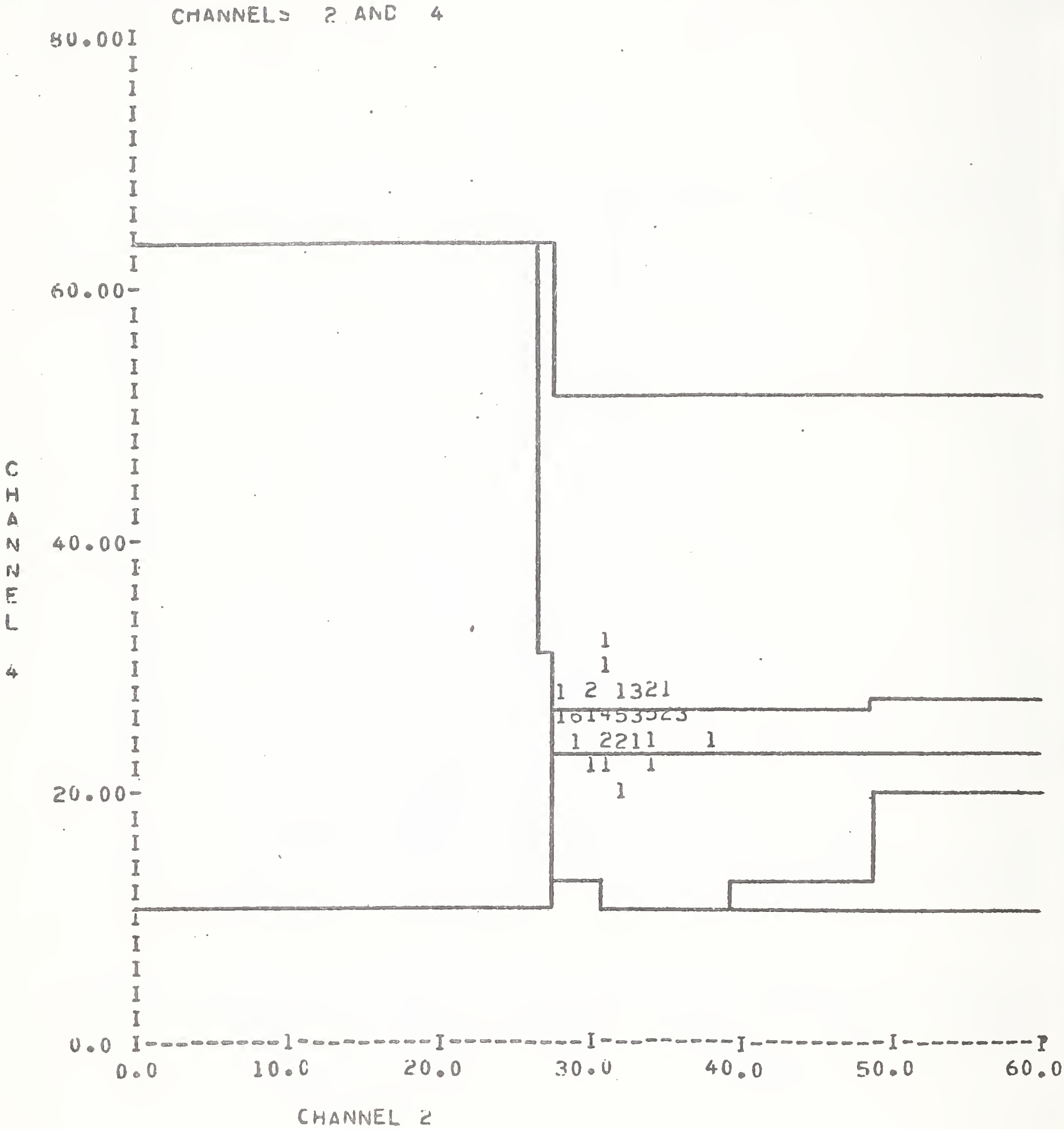

FIGURE 12. EXAMPLE 2-D HISTOGRAM FOR RESIDENTIAL

2-D HISTOGRAM FOR CATEGORY 6. MINE TAILINGS PO TRAINING AREA
NO.OF OBSERVATIONS= 12

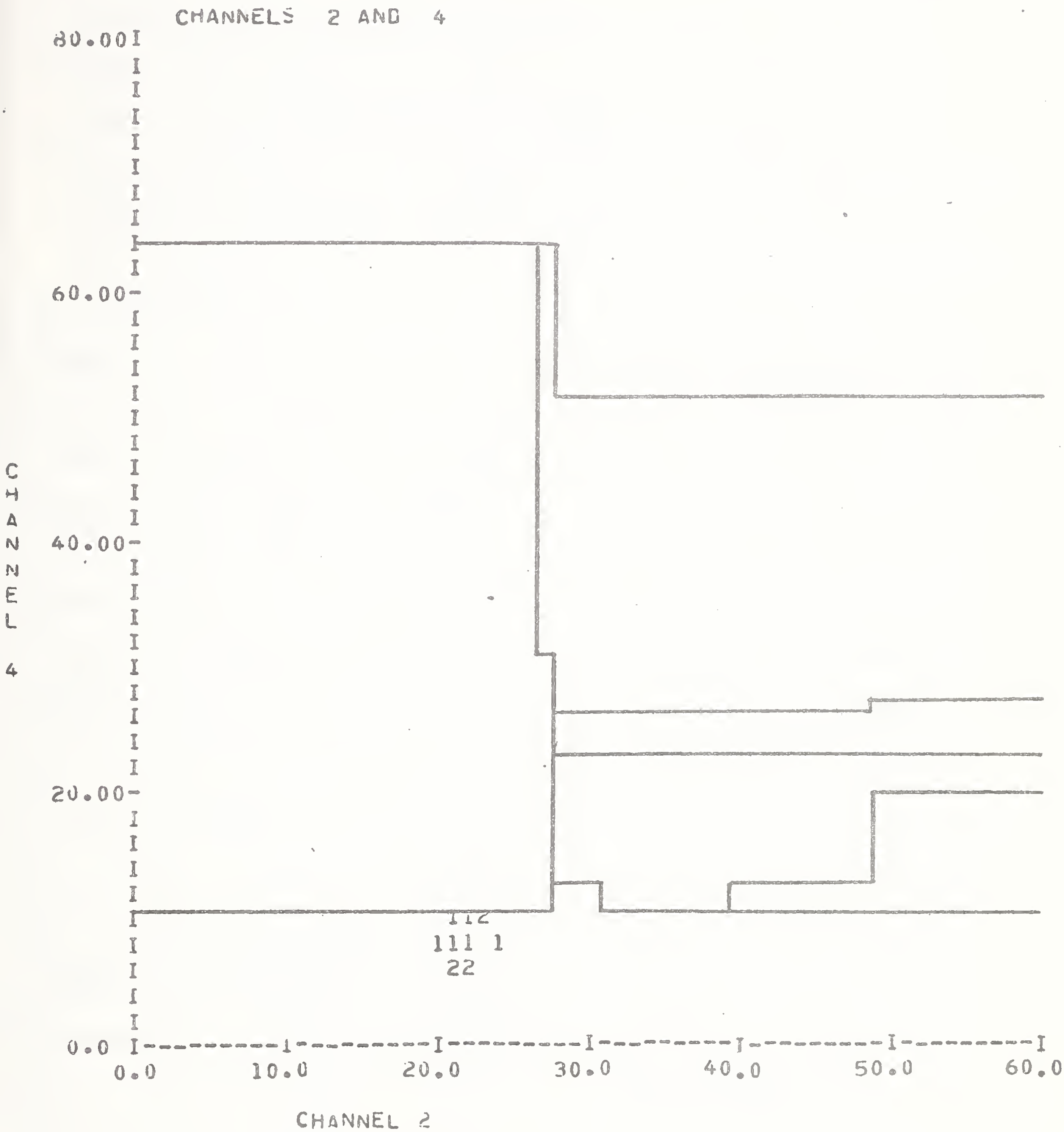

FIGURE 13. EXAMPLE 2-D HISTOGRAM FOR MINE TAILINGS POND

Land Cover Data Files

The final land cover map must be in machine-readable form for computing the CN's with CNPROG. The PPD program has been modified to produce land cover data files that can be used in CNPROG. The modified PPD program is called PPDSAV. PPDSAV writes the line printer map images to logical units 20 and 21; unit 20 contains the second map strip. If only one map strip is produced, then only unit 20 is used.

There should be a separate file for each map strip in the study area. The control cards for PPDSAV are identical to the PPD control cards. An example input file for PPDSAV is shown in Figure 14. The "CATEGORY" card specifies the category (i.e., land cover type) number, map symbol for use on the line printer map, and the category name. The "LOWER" and "UPPER" cards specify the lower and upper spectral bounds, respectively, for a category. Because the "CHANNELS" card specifies use of only channels 2 and 4, the spectral bounds on each "LOWER" and "UPPER" card specifies the bounds for channels 2 and 4.

PPDSAV also produces the line printer maps. The line and element limits of each map strip should be noted because this information is required in running CNPROG. CNPROG also requires as input the format specifications of the land cover files. The land cover file format that should be input to CNPROG when using PPDSAV is (1X, I5, 2X, 122A1).

The generation of the land cover data files is the last step of the Landsat land cover analysis. The land cover data files must be coordinated with the watershed data files. The procedure for generating the watershed data files is explained later.

```
//SEANHTB5 JOB (4071090299,RJ029),'BONDELID',MSGLEVEL=(1,1),
//   CLASS=B,TIME=(,20)
/*ROUTE  PRINT RMT29
//JOBLIB DD DSN=SEANH02.DRSER2,DISP=SHR
//STEP1 EXEC PGM=PPDTRB,REGION=300K
//FT06F001 DD SYSOUT=A
//FT08F001 DD UNIT=TAPE9,VOL=SER=028758,DSN=ARS38.PADG1R,
//    LABEL=(1,SL,,IN),DISP=(OLD,KEEP)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=FA,BLKSIZE=133)
//FT20F001 DD DSN=SEANH02.TRB.AREA2S3.DATA,UNIT=SYSDA,
//    DCB=(RECFM=FB,LRECL=132,BLKSIZE=3036),SPACE=(3036,(50,20),RLSE),
//    DISP=(NEW,CATLG)
//FT21F001 DD DSN=SEANH02.TRB.AREA2S4.DATA,UNIT=SYSDA,
//   DCB=(RECFM=FB,LRECL=132,BLKSIZE=3036),SPACE=(3036,(50,20),RLSE),
//    DISP=(NEW,CATLG)
//FT05F001 DD *
BLOCK      817 1134 1768 1989     1     1
CHANNELS    2    4
CATEGORY 1 = WATER
LOWER       1          0.1        .01
UPPER       1         78.0       10.6
CATEGORY 2 * FOREST
LOWER       2          .01      10.65
UPPER       2         26.5       63.5
CATEGORY 3 . AGRICULTURE
LOWER       3         28.5       27.6
UPPER       3         78.5       51.6
CATEGORY 4 O URBAN
LOWER       4         30.5      10.61
UPPER       4         38.5       13.2
CATEGORY 5 O URBAN
LOWER       5         27.5       13.2
UPPER       5         48.8        23.
CATEGORY 6 / LIGHT RESID.
LOWER       6         27.5       23.1
UPPER       6         48.8        26.
CATEGORY 7 = WATER
LOWER       7         28.5      10.65
UPPER       7         30.2      13.15
CATEGORY 8 * FOREST
LOWER       8         26.4      10.65
UPPER       8         27.9       29.4
CATEGORY 9 . AGRICULTURE
LOWER       9         26.4       29.5
UPPER       9        28.49       63.5
CATEGORY10 . AGRICULTURE
LOWER      10         27.9       26.1
UPPER      10         48.8       27.5
CATEGORY11 . AGRICULTURE
LOWER      11         48.9        23.
UPPER      11          78.       27.5
CATEGORY12 O URBAN
LOWER      12         48.9        20.
UPPER      12          78.       22.9
END
/*
```

FIGURE 14.   EXAMPLE PPDSAV INPUT FILE

CNPROG USER'S GUIDE

CNPROG can be used for processing the watershed data, generating line printer maps, and computing CNs. The subwatershed and soils data file requirements will be discussed in this section. A full description of the remaining CNPROG input requirements, program limitations, and output products is also presented in this section.

CNPROG Limitations

CNPROG has upper limits for several parameters. These upper limits are generally based on limiting the computer storage requirements, while still being able to meet most of the anticipated requirements. The total map width is limited by the maximum number of elements per strip and the maximum number of strips. The maximum number of elements allowed per map strip is 120; this limitation is due to the physical size of line printer output. The maximum number of map strips allowed is seven, so the maximum number of elements (the map width) is 840. There are no limits on the number of lines in a map.

There are no limits on the size of any subarea or soil area, although the maximum number of total boundary points for all subareas, including interpolated points, is currently set at 6000.

The number of soil types is limited to the four hydrologic soil types A, B, C, and D. The maximum number of subareas allowed is 36; this limitation is set by the number of available discrete maps symbols. There are no limits to the number of closed polygons allowed per subarea.

CNCALC can consider a maximum of ten land cover types. If more than ten land cover types are needed, then the arrays in CNCALC can be easily redimensioned to whatever value is needed.

In any program execution there are no limits to the number of calls or the sequence of calls, to any of the three processors. Thus, any number of analyses, or combinations of analyses, can be performed in one program execution.

CNPROG Input

The user controls the execution and input sequences by entering simple English language commands. CNPROG is versatile in several respects. The sequence of commands, and hence the input sequence, is, in general, up to the user. The formats and logical unit numbers of input data files are user defined. Also, the program has numerous checks on the validity and consistency of the input data so that incorrect data entry will usually not result in a termination of the entire run.

The CNPROG commands and basic input requirements will be detailed in this section. The required data files depend upon the CNPROG options selected. The data files will be discussed in the next section.

There are two types of commands; main commands and processor commands. The main commands are used to invoke the desired processor or to stop program execution. The processor commands are used within a processor; each processor has a unique set of commands.

The basic input sequence is as follows: first, a main command is entered which invokes the desired processor. Next, a series of processor commands and data is entered until the processing is complete. Control is then returned to the main program, and either another processor is invoked, or execution is terminated by the command STOP. Any number of calls to the processors can be performed in a single program execution.

Command Notation

Each command is an alphabetic string of characters that starts in column one. Several commands specify that particular input data is to be entered. All integer input must be right-justified; the last digit of the number should be in the last column of the data field specified. All real valued input should include the decimal point.

All of the CNPROG commands are described below. The descriptions include the purpose of the command, the program response, and the required user response.

MAIN Command:

1. Command: FILEGEN

Purpose: for generating point record files for subareas or soils.

Program Response: calls the sequence of subroutines that constitute the FILEGEN processor.

User Response: as required by the FILEGEN processor.

Comments: A subarea or soils boundary coordinate file and a write-enabled output file must be accessible to the FILEGEN processor. The output file requires a logical record length of 80.

2. Command: MAPGEN

Purpose: for generating subarea or soils maps.

Program Response: calls the MAPGEN subroutine.

User Response: as required by the MAPGEN processor.

Comments: a FILEGEN produced file must be accessible.

3. Command: CNCALC

Purpose: for calculating runoff curve numbers and associated data.

Program Response: call the CNCALC subroutine.

User Response: as required by the CNCALC processor.

Comments: A land cover file, FILEGEN produced subarea file, and either a FILEGEN produced soils file or a soil percentage file, must be accessible.

4. Command: TTY

Purpose: puts the CNPROG execution in a "teletype" mode.

Program Response: sets the "TTY" flag to "on".

User Response: None.

Comments: in the "teletype" mode, the program will prompt the user for all input commands and data.

4. Command: STOP.

   Purpose: to stop program execution.

   Program Response: immediately stops program execution.

   User Response: none.

   Comments: none.

FILEGEN Commands

The FILEGEN processor consists of two phases. The first phase is the processing of the boundary point data. The second phase divides the processed boundary data into map strips, and then writes the scan line record file. There is a separate set of commands for each phase.

Phase I Commands

1. Command: H

   Purpose: this is a "help" command

Program Response: lists the nine FILEGEN phase I commands.

User Response: enter a new phase I command.

Comments: none.

2. Command: STOP

Purpose: for exiting the FILEGEN processor before actual boundary file file processing begins.

Program Response: immediately returns control to the main program.

User Response: enter a new MAIN command.

Comments: none.

3. Command: GO

Purpose: to perform the actual processing of the boundary coordinate file.

Program Response: reads, processes, and sorts the boundary coordinate file. The FILEGEN phase II processor is then automatically invoked.

User Response: input a FILEGEN phase II command after phase I processing is complete.

Comments: all other desired phase I comments must be entered prior to the GO command. If INFILE=5, place the boundary point cards immediately after this GO command.

4. Command: INFILE

Purpose: to specify the logical unit number of the boundary coordinate file.

Program Response: reads the logical unit number in columns 1-2.

User Response: input an integer value in columns 1-2. The value must be right-justified.

Comments: if this command is not entered, then the default unit number is 3.

5. Command: SHIFT

Purpose: shifts the input boundary coordinate line and element values by specified amounts.

Program Response: reads the line and element shift values. The shift values will be added to each input boundary coordinate.

User Response: input the number of lines to shift in columns 1-5 and the number of elements to shift in columns 6-10. The values must be right-justified.

Comments: positive values will shift the line and element boundary values down and to the right. Negative values shift up and to the left.

6. Command: OUTFILE

Purpose: specifies the logical unit number of the output scan line record file.

Program Response: reads the logical unit number of the point record file.

User Response: input an integer value in columns 1-2. The value must be right-justified.

Comments: if this command is not used, then the default unit number is 4. The output files require a logical record length of 80.

7. Command: SOILS

Purpose: specifies that the boundary coordinate file is a soils file.

Program Response: reads the background soil type and sets the flag that specifies that soils data is being processed.

User Response: enter the background soil type (A, B, C, or D) in column 1.

Comments: if this command is not used, the input boundary file is assumed to be a subarea file. The background soil type is the type assigned to all pixels that are not within any file. The soils boundary file needs to contain the boundaries for only those soil types that differ from the background soil type.

8. Command: DIGITIZER

Purpose: used when the boundary coordinates are digitizer x and y values instead of the map image line and element values.

Program Response: reads two sets of coordinates; these sets are used for transforming the input x and y values to the line and element values.

User Response: enter two sets of coordinates; each set consists of an element (col. 1-5) and line (col. 6-10) and the corresponding digitizer x value (col. 11-15) and y value (col. 16-20). The element and line values are integers. The x and y values are real and should include the decimal point.

Comments: if this option is not specified, then actual line and element values are assumed in the boundary coordinate file.

9. <u>Command</u>: FORMAT

<u>Purpose</u>: to input the format specifications of the boundary coordinate file.

<u>Program Response</u>: reads the boundary coordinate file format.

<u>User Response</u>: input the format specifications, including the parentheses in columns 1-80.

<u>Comments</u>: if DIGITIZER is specified, the format must read real values (F format). If DIGITIZER is not specified, the format must read integer values (I format).

The FORMAT command <u>must</u> be specified prior to the GO command.

<u>FILEGEN Phase II Commands</u>

Phase II is automatically invoked after all processing from a phase I GO command is completed.

1. <u>Command</u>: LFBNDS

<u>Purpose</u>: for specifying the line and element limits in the land cover file.

Program Response: reads the line, element, and map strip data.

User Response: several lines of data must be entered:

Line 1: enter the first line (col. 1-5) and last line (col. 6-10) on the land cover file.

Line 2: enter the number of map strips (max. = 7) in the land cover file (col. 1).

Lines 3-N: enter the first element for map strip 1, the first element for map strip 2, etc., with one line for each strip. Each value is entered in columns 1-5.

Line N+1: enter the last element of the last map strip in columns 1-5.

Comments: all values are integer and must be right-justified.

2. Command: GO

Purpose: writes the scan line record file to the unit specified by the phase I OUTFILE command.

Program Response: divides the processed boundary point data into map strips, fills in the values between boundary points, and writes the scan line record file. Control is then returned to the main program.

User Response: after all processing is completed, enter a new MAIN command.

Comments: LFBNDS must be entered before the GO command.

3. Command: STOP

Purpose: for returning to the main program without using the GO command.

Program Response: immediately returns control to the main program.

User Response: enter a new MAIN command.

Comments: none

MAPGEN Commands

The MAPGEN processor produces line printer maps from the soils or subarea scan line files. The map strip line and element values of the MAPGEN maps will be the same as those for the land cover map.

1. Command: INFILE

Purpose: to specify the logical unit number of the FILGEN produced scan line from which the map will be generated.

<u>Program Response</u>: reads the logical unit number of the scan line file.

<u>User Response</u>: input the logical unit number in columns 1-2.

<u>Comments</u>: if this command is not entered, the default unit number is 3.

2. <u>Command</u>: PRINTFILE

<u>Purpose</u>: directs map output to a logical unit other than 6. This is especially useful when the user wants the map directed to a line printer instead of printing the map on the interactive terminal.

<u>Program Response</u>: reads the logical unit number to which the map output will be written.

<u>User Response</u>: input the logical unit number in columns 1-2.

<u>Comments</u>: if this command is not entered the default unit is 6.

3. <u>Command</u>: GO

<u>Program Response</u>: reads the soils or subarea scan line record file and generates the map.

<u>User Response</u>: after the map has been written, enter a new MAIN command.

Comments: if the printfile is a unit other than 6, a message is output to unit 6 stating that the map has been written.

4. Command: STOP

   Purpose: for exiting the MAPGEN processor before a map is generated.

   Program Response: immediately returns control to the main program.

   User Response: enter a new MAIN command.

   Comments: none

CNCALC Commands

The CNCALC processor computes runoff curve numbers and associated data. CNCALC requires a land cover file, a subarea scan line file, and either a soils scan line file or a soils percent table.

1. Command: H

   Purpose: this is a "help" command.

   Program Response: prints a list of all CNCALC commands.

User Response: none

Comments: none

2. Command: FORMAT

Purpose: specifies the format of the land cover file.

Program Response: reads the land cover file format.

User Response: input the land cover file format (including parentheses) in columns 1-80.

Comments: this command must be entered prior to the GO command. The format statement must be set up so that the line number is read as an integer followed by reading a string of alphameric characters. Each character is read in an A1 format. The following example illustrates the format requirements:

(I7, 2x, 120A1)

3. Command: SOILFILE

Purpose: reads the logical unit number of the soils scan line record file. Also, this command indicates that CN's will be based on a soils scan line file rather than a soils percent table.

Program Response: reads soils scan line unit and sets flag.

User Response: input the soils scan line unit in columns 1-2.

Commands: if this command is not entered, the program assumes the CN calculations will be based on a soils percent table.

4. Command: SOILTABLE

Purpose: specifies the logical unit number of the soils percent table.

Program Response: reads the soils percent table unit number and then reads the soils percent table. Each line of the table consists of the subarea number (col. 1-5), the percent of soil types A (col. 6-10), B (col. 11-15), C (col. 16-20), and D (col. 21-25). The program continues to read table values until it encounters either a blank line or an end-of-file. The subarea numbers do not have to be in any particular order. The subarea numbers are integer and the percentages are real.

User Response: enter the soils percent table unit number in columns 1-2. If unit 5 is specified, the soils table should be entered starting on the next line. A blank line signifies the end of the table.

5. Command: CNTABLE

Purpose: To specify the CN values for each soil type and alphameric land use symbol.

Program Response: reads the CN table on unit 5; each line consists of an alphameric symbol in col. 1, and the corresponding CN values for soil types A (col. 2-5), B (col. 6-10), C (col. 11-15), and D (col. 16-20). A blank line signifies the end of the CN table. The CN values are real, and should include the decimal point. The alphameric symbols do not have to be input in any particular order.

User Response: enter the CN table with the last line being blank.

Comments: If this command is not entered, then the default table shown in Table 3 is used.

6. Command: LANDFILE

Purpose: specifies the logical unit number of the land cover file.

Program Response: reads the land cover file unit number.

User Response: enter the land cover file unit number in columns 1-2.

Comments: if this command is not entered, the default unit number is 4.

7. Command: AREAFILE

Purpose: specifies the logical unit number of the subarea scan line file.

Program Response: reads the subarea scan line file unit number.

User Response: enter the scan line file unit number in columns 1-2.

Comments: if this command is not entered, the default unit number is 2.

8. Command: GO

Purpose: to perform the CN computations.

Program Response: reads the scan line file, computes CN's, and prints summary tables.

User Response: after all processing is complete, enter a new MAIN command.

Comments: the commands FORMAT, CNTABLE, and either SOILFILE or SOILTABLE must be entered prior to the GO command.

9. Command: STOP

Purpose: to exit the CNCALC processor before actual CN calculations are performed.

Program Response: immediately returns control to the main program.

Program Response: reads the CN table on unit 5; each line consists of an alphameric symbol in col. 1, and the corresponding CN values for soil types A (col. 2-5), B (col. 6-10), C (col. 11-15), and D (col. 16-20). A blank line signifies the end of the CN table. The CN values are real, and should include the decimal point. The alphameric symbols do not have to be input in any particular order.

User Response: enter the CN table with the last line being blank.

Comments: If this command is not entered, then the default table shown in Table 3 is used.

6. Command: LANDFILE

Purpose: specifies the logical unit number of the land cover file.

Program Response: reads the land cover file unit number.

User Response: enter the land cover file unit number in columns 1-2.

Comments: if this command is not entered, the default unit number is 4.

7. Command: AREAFILE

Purpose: specifies the logical unit number of the subarea scan line file.

Program Response: reads the subarea scan line file unit number.

User Response: enter the scan line file unit number in columns 1-2.

Comments: if this command is not entered, the default unit number is 2.

8. Command: GO

Purpose: to perform the CN computations.

Program Response: reads the scan line file, computes CN's, and prints summary tables.

User Response: after all processing is complete, enter a new MAIN command.

Comments: the commands FORMAT, CNTABLE, and either SOILFILE or SOILTABLE must be entered prior to the GO command.

9. Command: STOP

Purpose: to exit the CNCALC processor before actual CN calculations are performed.

Program Response: immediately returns control to the main program.

User Response: enter a new MAIN command.

Comments: none

The complete set of CNPROG commands is summarized in Fig. 15. There are a total of 30 commands.

Start

FILEGEN	MAPGEN	CNCALC	STOP
Phase I:	INFILE	H	
H	PRINTFILE	FORMAT	
STOP	GO	SOILFILE	
GO	STOP	SOILTABLE	
INFILE		CNTABLE	
SHIFT		LANDFILE	
OUTFILE		AREAFILE	
SOILS		GO	
DIGITIZER			
FORMAT			
Phase II:			
LFBNDS			
GO			
STOP			

FIGURE 15. CNPROG Command Summary

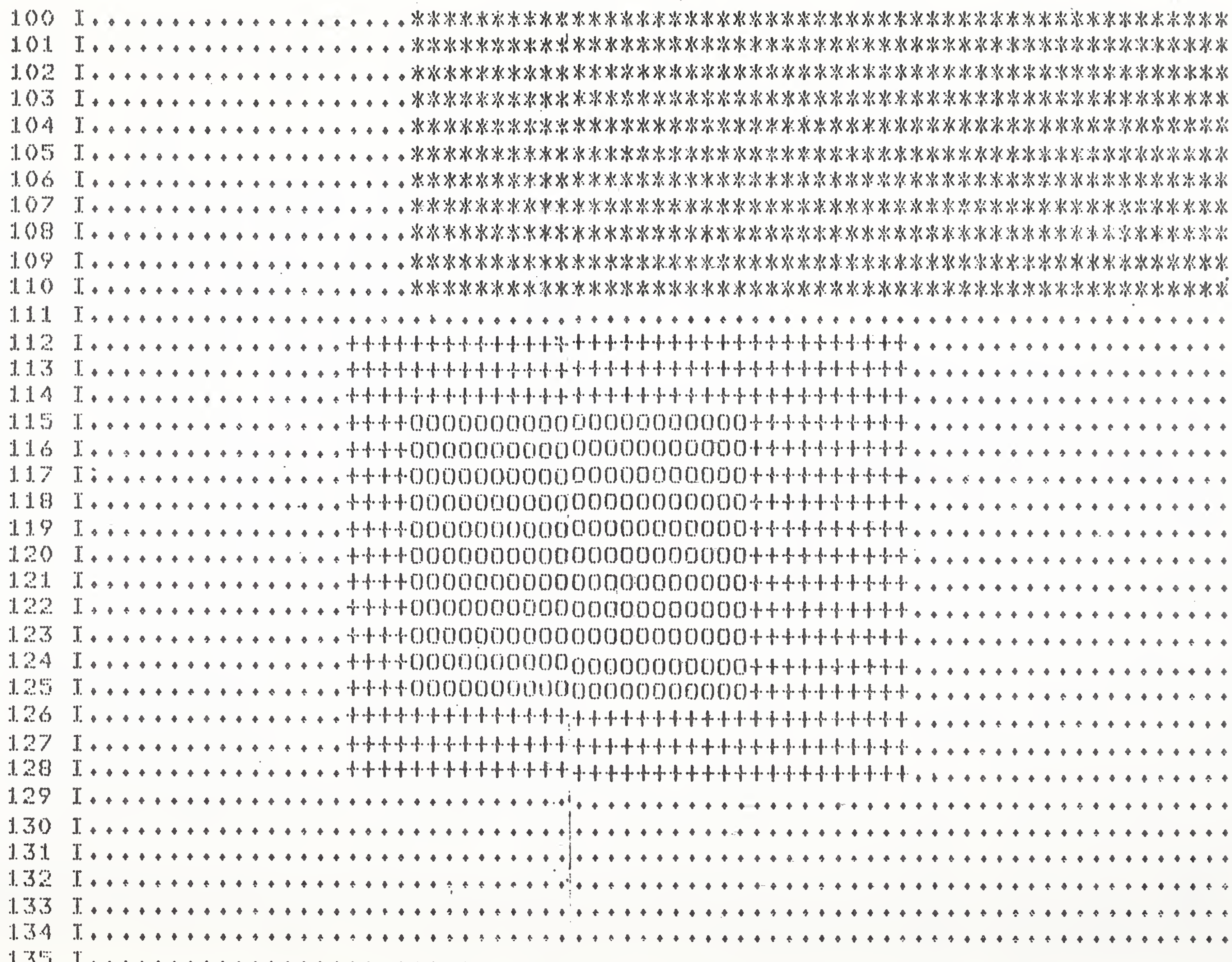

FIGURE 17. EXAMPLE LAND COVER MAP

Soils Data Files

The soils data can be input in two different ways. The first way is to use a FILEGEN soils file in which each point is a particular soil group. The second way is to input a soil percent table. The table contains the percentages of each soil type for each subarea. The CN for a particular point in a particular subarea is based on a weighted average CN for the land cover type for that subarea. The weighted average CN is based on the soil percentages and the CN table values.

Land Cover-CN Table

A table specifying the CN for each land cover and soil type is needed for computing CN's. CNPROG contains the default land cover-CN table that is used if a table is not specified in the CNPROG input. This default table is shown in Table 3.

TABLE 3. Default Land Cover-CN Table

		Soil Group			
Map Symbol	Land Cover Type	A	B	C	D
*	Forest	25	55	70	77
.	Agriculture	36	60	73	78
+	Residential	60	74	83	87
0	Highly Impervious	90	93	94	94

In addition to computing CN's the CNCALC processor also computes other desirable information. For each subarea and for the watershed as a whole, CNCALC computes soil percentages, land cover percentages, total number of classified pixels, and total number of pixels.

Boundary Point Files

The accuracy of the CN estimates is highly dependent on how accurately the soils and subarea boundary points correspond to the points on the land cover file. That is, the line and element values in all files should refer to the same points geographically.

The most accurate procedure for determining boundary points is to draw the boundaries on the land cover line printer map. The boundary point line and element values can then be determined accurately and consistently.

The user can either input the boundary point line and element values or place a map on a digitizer and trace the boundary points with the cursor. If a digitizer is used, then CNPROG must transform the boundary points from the digitizer x and y coordinates to the land cover map line and element coordinates.

The basic boundary point input sequence consists of inputting all of the boundary points for a subarea or soils region followed by the boundary points for either a different region for the same subarea or soil type, or the boundary points for a new subarea or soil type region.

Numbering of Subareas. The user must assign a unique number to each subarea. The subareas can be assigned numbers from 1 to 999. The subareas do not have to be numbered in any particular order. CNPROG assigns an index value to each subarea based on the order in which the subarea boundaries are entered. These index values are used for computational purposes; all user input should be in terms of the user's subarea numbers rather than the CNPROG index values.

Numbering of Soils Areas. The soil group regions should be numbered from 1 to 4. The numbers 1, 2, 3, and 4 correspond to soil group A, B, C, and D, respectively. All of the regions for a particular soil group should be grouped together on the boundary point file. All of the closed regions for one soil group should be input, then all of the closed regions for a different soil type should be input, etc.

Background Hydrologic Soil Group. The background soil group (A, B, C, or D) should be the predominant soil group in the watershed. The user needs to input boundary point data for only the regions where the soil group is different from the background soil group. The background soil group is specified by the user in the CNPROG input.

File Structure

The boundary point file structure depends on if the boundary points are line and element values or digitizer coordinates. A basic difference is that the line and element values are input as integers, whereas the digitizer coordinates are input as real values.

Line and Element Files. The user can specify the format of the boundary file with some restrictions. The format specification must read three integer values on each line; the first value is the line number, the second value is the element, and the third value is either the user-defined subarea number or the soil group number. The last boundary point for a closed region must be the same as the first boundary point for the region. The subarea or soil number only needs to be entered on the first boundary point for a region.

Digitizer Files. The digitizer file structure is quite different from the line and element file structure. The first line for a closed region should have the subarea or soil number in columns 8-9. The subsequent lines should contain digitizer x and y values. Each line of digitizer values should contain eight sets of x and y values. The end of input boundary points for a closed region is indicated in the input file by a zero x value. The region is then automatically closed in CNPROG.

Soil Group Percent File. A table containing the percentages of the hydrologic soil groups can be used in place of a soil group boundary point file. Each line in this file should contain the soil group percentages for one subarea. The reguired format for each line is given in Table 4.

TABLE 4. Soil Group Percent Input Format

Col.	Description of Contents
1-5	Subarea number, integer format
6-25	4 five-column real fields in which the first value is the percent of soil group A, the second is the percent of soil group B, etc.

Example Files

Figures 18 and 19 present example line and element files for subareas and soils, respectively. Figure 20 presents an example digitizer subarea file. The required format specifications are included in each figure.

106	1508	1
108	1513	1
123	1513	1
125	1529	1
130	1529	1
125	1502	1
106	1508	1
108	1514	2
105	1537	2
113	1535	2
121	1514	2
108	1514	2
102	1538	3
102	1542	3
101	1546	3
101	1552	3
104	1549	3
110	1549	3
112	1536	3
102	1538	3
105	1550	4
105	1560	4
116	1566	4
129	1544	4
126	1538	4
122	1514	4
113	1536	4
110	1550	4
105	1550	4
130	1544	5
133	1538	5
131	1530	5
125	1530	5
127	1538	5
130	1544	5

FORMAT:
(3I5)

FIGURE 18. EXAMPLE SUBAREA BOUNDARY POINT FILE

100	1508	1
100	1570	1
116	1570	1
124	1562	1
104	1508	1
100	1508	1
113	1522	1
118	1530	1
120	1524	1
116	1518	1
113	1522	1
135	1518	2
133	1520	2
118	1545	2
130	1548	2
135	1554	2
135	1518	2

FORMAT:
(3I5)

FIGURE 19. EXAMPLE SOILS BOUNDARY POINT FILE

```
2234 1227 2212 1243 2182 1257 2165 1272 2114 1273 2082 1291 2062 1306 2040 1403
2020 1420 2022 1440 2042 1467 2052 1504 2062 1543 2053 1561 2025 1591 2002 1600
1972 1627 1943 1642 1932 1661 1934 1774 1944 1824 1941 1858 1947 1920 1929 1937
1934 1964 1960 2008 1976 2024 2013 2057 2033 2091 2073 2093 2101 2073 2119 2072
2159 2023 2171 1992 2176 1967 2172 1922 2164 1389 2168 1824 2181 1789 2191 1773
2202 1757 2222 1737 2260 1689 2291 1651 2321 1617 2349 1566 2367 1531 2370 1483
2389 1433 2392 1401 2425 1353 2434 1319 2442 1244 2412 1252 2366 1272 2354 1278
2339 1271 2317 1250 2285 1234
SUBAREA 2
2180 1805 2169 1841 2171 1904 2160 1941 2183 1974 2173 2003 2152 2042 2121 2075
2123 2105 2141 2143 2181 2186 2211 2209 2250 2239 2292 2232 2343 2235 2379 2199
2423 2167 2459 2147 2476 2141 2511 2163 2542 2152 2570 2117 2599 2098 2630 2093
2601 2051 2572 2017 2540 2000 2501 2000 2481 1933 2419 1967 2387 1960 2364 1937
2363 1904 2396 1850 2404 1828 2402 1773 2395 1722 2364 1738 2334 1752 2294 1784
2259 1806 2227 1818 2195 1812
SUBAREA 3
2400 1719 2404 1801 2409 1836 2380 1863 2362 1904 2369 1934 2389 1960 2479 1978
2501 1994 2551 2001 2580 2018 2616 2068 2631 2092 2720 2135 2831 2200 2844 2217
2862 2250 2937 2266 2980 2301 2999 2321 2998 2332 3025 2332 3058 2303 3091 2316
3124 2328 3158 2316 3161 2300 3156 2268 3124 2185 3111 2136 3116 2101 3120 2051
3108 2034 3070 2018 3031 1999 2990 1985 2969 1975 2933 1949 2840 1934 2801 1922
2763 1904 2713 1885 2681 1870 2616 1838 2590 1821 2564 1768 2520 1740 2480 1720
2432 1718
SUBAREA 4
2446 1239 2442 1298 2431 1349 2400 1400 2390 1415 2383 1468 2365 1496 2373 1534
2352 1572 2323 1620 2285 1667 2270 1687 2240 1719 2198 1767 2180 1802 2218 1812
2255 1805 2303 1773 2354 1737 2382 1721 2425 1710 2479 1716 2523 1737 2560 1754
2569 1720 2572 1685 2550 1654 2524 1621 2513 1603 2520 1556 2492 1566 2493 1549
2533 1515 2563 1481 2594 1434 2610 1390 2588 1366 2571 1336 2571 1285 2562 1269
2533 1252 2474 1237
SUBAREA 5
2650 1267 2831 1319 2822 1337 2799 1353 2741 1355 2711 1374 2621 1380 2594 1436
2561 1483 2536 1516 2499 1545 2497 1562 2520 1552 2520 1582 2519 1609 2546 1651
2572 1671 2574 1703 2570 1723 2568 1753 2571 1773 2601 1822 2630 1841 2659 1854
2717 1886 2782 1905 2803 1920 2834 1931 2936 1950 2970 1976 3017 1997 3081 2013
3092 1952 3107 1925 3092 1907 3062 1890 3048 1875 3049 1852 3063 1801 3074 1756
3035 1701 3044 1634 3051 1600 3071 1568 3106 1548 3128 1530 3150 1499 3170 1466
3201 1430 3201 1414 3150 1402 3106 1366 3078 1364 3052 1353 3001 1354 2971 1367
2941 1363 2914 1324 2898 1290 2871 1270
SUBAREA 6
3408 1360 3387 1374 3358 1384 3339 1403 3320 1410 3298 1399 3259 1386 3229 1401
3209 1418 3202 1436 3171 1466 3150 1504 3134 1533 3070 1574 3060 1598 3049 1617
3038 1700 3072 1751 3068 1788 3059 1821 3050 1855 3051 1879 3109 1921 3249 1937
3280 1934 3300 1900 3298 1783 3288 1714 3290 1697 3318 1650 3349 1616 3385 1600
3412 1591 3434 1587 3452 1576 3525 1573 3567 1534 3601 1533 3619 1520 3619 1468
3559 1426 3517 1405 3437 1370
SUBAREA 7
2323 1091 2306 1117 2264 1163 2234 1219 2306 1239 2344 1268 2365 1269 2465 1235
2494 1238 2563 1266 2574 1283 2573 1336 2590 1366 2610 1388 2651 1377 2712 1374
2741 1353 2791 1354 2817 1333 2633 1301 2849 1264 2781 1231 2767 1212 2728 1210
2733 1119 2751 1087 2741 1069 2712 1052 2701 1019 2671 1053 2651 1072 2630 1087
2561 1095 2533 1110 2502 1109 2473 1087 2453 1089 2424 1104 2354 1109
SUBAREA 8
2330 0926 2357 0959 2354 0978 2327 0992 2321 1087 2355 1106 2425 1104 2454 1083
2474 1086 2503 1108 2551 1102 2639 1080 2672 1051 2710 1008 2752 0954 2774 0927
2734 0886 2684 0842 2634 0840 2610 0850 2591 0886 2509 0875 2490 0885 2443 0888
2426 0870 2444 0852 2452 0825 2404 0836 2361 0853 2345 0874 2335 0893
```

FORMAT: (16F5.2)

FIGURE 20. EXAMPLE DIGITIZER BOUNDARY POINT FILE

CNPROG Input Sequence

Figure 21 shows a general sequence of CNPROG commands that can be used for a complete CNPROG analysis. The complete analysis sequence processes soils and subwatershed boundary points, produces line printer maps, and performs the CN analyses. The sequence showed only one of many possible sequences because the CNPROG commands can be placed in almost any desired order prior to a "GO" command.

Figures 22, 23, and 24 are sample input coding forms for the FILEGEN, MAPGEN, and CNCALC processors, respectively. These forms can be used for keypunching CNPROG input files.

Example CNPROG Runs

Four example runs are presented in this section. The first three runs were performed interactively using the University of Maryland UNIVAC 1100/42 computer. The user inputs are in lower case letters and the CNPROG outputs are in upper case letters. The fourth example run was executed in a batch mode on an IBM 370 computer.

The runs are based on the simplified example data contained in Figures 16, 18, and 19. The runs are designed to illustrate most of the features and options in CNPROG. The CNPROG prompts and outputs shown in the examples are self-explanatory.

Table 5 shows the file numbering system used in all runs. This particular numbering system is arbitrary; the user must supply the appropriate computer system commands to associate the unit numbers with correct files.

The land cover classifications for the examples are shown in Table 6. The CN's associated with these land uses are shown in Table 3.

	COMMAND	PROCESSOR	COMMENTS
1	FILEGEN	FILEGEN	Processes soil
2	INFILE		group boundary
3	OUTFILE		point data and
4	SHIFT		generates soils
5	SOILS		FILEGEN file
6	DIGITIZER		
7	FORMAT		
8	GO		
9	LFBNDS		
10	GO		
11	MAPGEN	MAPGEN	Produces soil
12	INFILE		group line printer
13	PRINTFILE		map
14	GO		
15	FILEGEN	FILEGEN	processes subarea
16	INFILE		boundary point
17	OUTFILE		data and generates
18	SHIFT		subarea FILEGEN
19	DIGITIZER		file
20	FORMAT		
21	GO		
22	LFBNDS		
23	GO		
24	MAPGEN	MAPGEN	Produces subarea
25	INFILE		line printer map
26	PRINTFILE		
27	GO		
28	CNCALC	CNCALC	Computes CN's,
29	FORMAT		land cover percents,
30	SOILFILE		and soil group
31	SOILTABLE		percents on a
32	CNTABLE		subarea basis
33	LANDFILE		
34	AREAFILE		
35	GO		
36	STOP	NONE	Stops CNPROG execution

FIGURE 21. GENERAL CNPROG COMMAND SEQUENCE

Coding form (cols. 1–25)	DESCRIPTION
FILEGEN	Invoke FILEGEN Phase I
H	"Help" command produces listing of FILEGEN options
INFILE	
	Boundary point input file number
OUTFILE	
	FILEGEN output file number
SHIFT	Enter only if all boundary points are to be shifted
	Enter line and element shift values
SOILS	Enter only if a soils boundary point file is to be processed
	Enter background soil type (A, B, C, or D) in col. I
DIGITIZER	Enter only if a digitizer (x-y) coordinate system is used
	Enter two sets of line-element and x-y values
FORMAT	
(	Enter boundary point input file FORMAT in col. 1-80
GO	Phase I processing; if INFILE = 5, place bound. cards after this line
LFBNDS	Phase II processor; specify land cover data file bounds
	Enter first line and last line of map strips
	Enter number of map strips in col. 1
	If the number of map strips is n, there should be n + 1 lines specifying map strip element limits; the first n lines specify the first element of each map strip. The last line specifies the last element of the last map strip.
GO	Phase II processing; control returned to main program

Figure 22. Coding Form for FILEGEN Processor

Columns 1–25	DESCRIPTION
MAPGEN	Invoke MAPGEN processor
INFILE	
	Enter input FILEGEN unit in col. 1-2.
PRINTFILE	Enter only if map output is to unit other than 6
	Enter map output file unit in col. 1-2
GO	Generate line printer map; control is returned to main program

Figure 23. Coding Form for MAPGEN Processor

Coding (col. 1–25)	DESCRIPTION
CNCALC	Invoke CNCALC processor
FORMAT	
(	Enter land cover file format
SOILFILE	Specifies that soils data is in FILEGEN file
	Enter FILEGEN soils file unit in col. 1-2
SOILTABLE	Specifies that soils data is in table of soil percentages
	Enter soil table file unit number in col. 1-2
	If soil table unit number is 5, enter one line for
	each subarea; each line contains a subarea
	number and the percentages for each soil group.
	The last line of the table should be blank.
CNTABLE	
	Enter a land cover symbol in col. 1 and the
	corresponding CN's for each soil group.
	The last line should be blank.
LANDFILE	
	Enter the land cover file unit number in col. 1-2
AREAFILE	
	Enter the subarea FILEGEN file number in col. 1-2
GO	Compute CN's; control returned to main program

Figure 24. Coding Form for CNCALC Processor

TABLE 5. Logical File Unit Numbers for Example Runs

Unit No.	Description
10	Land Cover File
11	Subarea Boundary Point File
12	Soils Boundary Point File
13	Subarea Scan Line File
14	Soils Scan Line File

TABLE 6. Example Land Cover Symbols

Symbol	Land Cover
*	Forest
.	Agriculture
+	Residential
0	Highly Impervious

The first three runs are presented in Appendix A. The UNIVAC execution statements that start each run are underlined to clearly indicate the start of a CNPROG execution. The three runs together constitute a complete CN analysis sequence. The analysis sequence could just as easily have been completed in one program execution; three runs are used to illustrate the versatility of CNPROG.

The first run generated the scan line file for the soils boundaries. The FILEGEN processor is used and then execution is terminated by the STOP command.

The second run uses MAPGEN to produce a map based on the scan line file created in the first run. Note that only three commands are necessary to produce the map: MAPGEN, INFILE, and GO.

The third run is much more extensive than the first two runs. First, the FILEGEN processor is used to produce the subarea scan line file. The MAPGEN processor is used next to produce a subarea map. The CNCALC processor is then called twice. The first call computes CN's based on the soils scan line file. The second call uses a soil percent table for computing CN's.

The fourth run is the batch mode equivalent of the first three runs. The entire process of generating the FILEGEN files, producing the maps, and calculating the CN's is performed in one execution. The input file including the necessary IBM JCL file control statements, is shown in Figure 25. The resultant output is shown in Appendix B. Note that most of the CNPROG prompts for input data are suppressed in the batch mode execution.

```
//SEANHTB7 JOB (XXXXXXXXXX,RJ029),'BONDELID',MSGLEVEL=(1,1),
//    CLASS=I,TIME=2,PRTY=2
/*ROUTE  PRINT RMT29
//JOBLIB DD DSN=SEANH02.TRB.CNLMOD.OBJ,DISP=SHR
//STEP1 EXEC PGM=CNPROG,REGION=300K
//FT06F001 DD SYSOUT=A
//FT12F001 DD DSN=SEANH02.CN.AREABND.DATA,DISP=SHR
//FT13F001 DD DSN=SEANH02.CN.SOILBND.DATA,DISP=SHR
//FT10F001 DD DSN=SEANH02.CN.SOILFILE.DATA,UNIT=SYSDA,
//   DISP=(NEW,CATLG),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120),
//   SPACE=(3120,(25,5),RLSE)
//FT11F001 DD DSN=SEANH02.CN.AREAFILE.DATA,UNIT=SYSDA,
//   DISP=(NEW,CATLG),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120),
//   SPACE=(3120,(25,5),RLSE)
//FT14F001 DD DSN=SEANH02.CN.LANDTEST.DATA,DISP=SHR
//FT05F001 DD *
FILEGEN
INFILE
13
OUTFILE
10
FORMAT
(3I5)
SOILS
D
GO
LFBNDS
  100  135
2
 1500
 1530
 1570
GO
FILEGEN
INFILE
12
OUTFILE
11
FORMAT
(3I5)
GO
GO
MAPGEN
INFILE
10
GO
MAPGEN
INFILE
11
GO
```

FIGURE 25.   EXAMPLE CNPROG INPUT FILE

```
CNCALC
FORMAT
(I5,2X,50A1)
SOILFILE
10
LANDFILE
   14
AREAFILE
11
CNTABLE
*   25    55    70    77
.   36    60    73    78
D   90    93    94    94
+   60    74    83    87

ED
STOP
/*
```

FIGURE 25.   (Continued)

SUMMARY

Previous studies have shown the potential of using remotely sensed data in hydrologic modeling. Several of these studies have focused on the SCS runoff Curve Number. The overall conclusion of these investigations was that remotely sensed data is a cost-effective alternative for determining the land cover required by the CN procedure.

In this report we described a computer based procedure for estimating CNs using remotely sensed data. The procedure utilizes a number of existing analysis routines and new procedures. These have been streamlined for this particular application. Descriptions and examples of each step in the analysis have been included.

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Cermak, R. J., Feldman, A. D., and Webb, R. P., 1979, Hydrologic Land Use Classification Using Landsat, Technical Paper No. 67, U. S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California.

Ragan, R. M., and Jackson, T. J., 1980, Runoff Synthesis Using Landsat and the SCS Model, Journal of the Hydraulics Division of the ASCE.

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Soil Conservation Service, 1975, Urban Hydrology for Small Watersheds; Technical Release No. 55.

U. S. Army Corps of Engineers, 1978, HYDDAR (Hydrologic Parameters) Users Manual, Hydrologic Engineering Center, Davis, California.

OUTPUT FOR EXAMPLE RUNS 1, 2, and 3

```
@ASG,A SOILBND.
READY
@ASG,UP SOILFILE.
READY
@USE 13,SOILBND.
READY
@USE 10,SOILFILE.
READY
@XQT LIB.CNPROG

  * CNPROG *  AN EASY-TO-USE SYSTEM FOR COMPUTING
  * CNPROG *   RUNOFF CURVE NUMBERS
  * CNPROG *   CONVERTS SPATIAL SOILS AND WATERSHED BOUNDS TO
  * CNPROG *   DIGITAL FORM FOR USE WITH DIGITAL LAND USE DATA

  ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN    MAPGEN    CNCALC    TTY    STOP
TTY
 TTY

  * CNPROG *  TELETYPE OPTION SELECTED

  ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN    MAPGEN    CNCALC    TTY    STOP
FILEGEN
 FILEGEN

  * CNPROG *  BOUNDARY FILE PROCESSOR:
 ENTER H FOR LIST OF OPTIONS

  ENTER BNDFIL OPTION:
H

  BNDFIL OPTIONS:
 H   STOP    GO    INFILE    SHIFT
 OUTFILE    SOILS    DIGITIZER    FORMAT

  ENTER BNDFIL OPTION:
INFILE

  ENTER BOUNDARY INPUT FILE UNIT IN COLS. 1-2
13

  ENTER BNDFIL OPTION:
OUTFILE

  ENTER SCAN LINE FILE OUTPUT UNIT IN COLS. 1-2
10

  ENTER BNDFIL OPTION:
FORMAT

  ENTER BOUNDFIL FORMAT
(3I5)
```

```
 ENTER BNDFIL OPTION:
SOILS

 ENTER BACKGROUND SOIL TYPE(A,B,C,OR D) IN COL. 1
D

 ENTER BNDFIL OPTION:
GO

 INPUT BOUNDARY POINT FILE = UNIT 13
 OUTPUT SCAN LINE FILE= UNIT 10

 BOUNDARY FILE FORMAT=(3I5)

 BACKGROUND SOIL TYPE= D

 INDEX     SUBAREA NUMBER
    1             1
    1             1
    2             2

 SOIL POINT FILE CONTAINS    104 RECORDS

 * CNPROG *  NUMBER OF RECORDS TO SORT=   104

 SORT COMPLETED

 * CNPROG *   FILEGEN OPTIONS:
LFBNDS    GO    STOP

 ENTER FILEGEN OPTION:
LFBNDS

 ENTER LAND COVER FILE LINEST(COL. 1-5) AND LINEND(COL. 6-10)
 100  135

 ENTER NUMBER OF STRIPS IN LAND COVER FILE(COL. 1)
2

 ENTER FIRST ELEMENT FOR STRIP 1(COL.1-5):
1500

 ENTER FIRST ELEMENT FOR STRIP 2(COL.1-5):
1530

 ENTER LAST ELEMENT FOR STRIP 2(COL.1-5):
1570

 ENTER FILEGEN OPTION:
GO
```

```
 OUTPUT FILE UNIT= 10

  LAND COVER FILE DATA:
 NSTRIP=  2
 LINEST=   100
 LINEND=   135

    STRIP    1ST ELEMENT    LAST ELEMENT
      1         1500            1529
      2         1530            1570

  * CNPROG *  SCAN LINE FILE IS WRITTEN

  ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN    MAPGEN    CNCALC    TTY    STOP
STOP
 STOP

NORMAL EXIT.  EXECUTION TIME:        1077 MILLISECONDS.
```

```
@XQT LIB.CNPROG

  * CNPROG *  AN EASY-TO-USE SYSTEM FOR COMPUTING
  * CNPROG *   RUNOFF CURVE NUMBERS
  * CNPROG *   CONVERTS SPATIAL SOILS AND WATERSHED BOUNDS TO
  * CNPROG *   DIGITAL FORM FOR USE WITH DIGITAL LAND USE DATA

  ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN    MAPGEN    CNCALC    TTY    STOP
TTY
 TTY

  * CNPROG *  TELETYPE OPTION SELECTED

  ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN    MAPGEN    CNCALC    TTY    STOP
MAPGEN
 MAPGEN

  * CNPROG *  MAPGEN OPTION
 ENTER ONE OF THE FOLLOWING OPTIONS
 INFILE    PRINTFILE    GO    STOP
INFILE

  ENTER INPUT FILE UNIT IN COL. 1-2:
10

  * CNPROG *  MAPGEN OPTION
 ENTER ONE OF THE FOLLOWING OPTIONS
 INFILE    PRINTFILE    GO    STOP
GO


 INPUT FILE UNIT= 10
 PRINT FILE UNIT=  6


   SOILS FILE CONTAINS  2 STRIPS
 1ST LINE=   100     LAST LINE=   135
  BACKGROUND SOIL TYPE IS D
```

SOILS MAP STRIP 1

```
 1500I1505I1510I1515I1520I1525I1530I
     I    I    I    I    I    I    I
100 I        AAAAAAAAAAAAAAAAAAAAAA
101 I          AAAAAAAAAAAAAAAAAAAA
102 I             AAAAAAAAAAAAAAAAA
103 I               AAAAAAAAAAAAAAA
104 I                 AAAAAAAAAAAAA
105 I                   AAAAAAAAAAA
106 I                      AAAAAAAA
107 I                        AAAAAA
108 I                          AAAA
109 I                            AA
110 I
111 I
112 I
113 I                      A
114 I                     AAAA
115 I                   AAAAAAA
116 I                  AAAAAAAAAA
117 I                    AAAAAAAAA
118 I                     AAAAAAAAA
119 I                       AAAAA
120 I                        A
121 I
122 I
123 I
124 I
125 I
126 I
127 I
128 I                            BB
129 I                           BBB
130 I                         BBBBB
131 I                       BBBBBBB
132 I                      BBBBBBBB
133 I                    BBBBBBBBBB
134 I                   BBBBBBBBBBB
135 I                  BBBBBBBBBBBB
```

SOILS MAP STRIP 2

```
 1530I1535I1540I1545I1550I1555I1560I1565I1570I
     I    I    I    I    I    I    I    I    I
100 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
101 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
102 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
103 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
104 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
105 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
106 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
107 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
108 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
109 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
110 I AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
111 I   AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
112 I     AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
113 I       AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
114 I          AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
115 I            AAAAAAAAAAAAAAAAAAAAAAAAAAAAA
116 I              AAAAAAAAAAAAAAAAAAAAAAAAAAA
117 I                AAAAAAAAAAAAAAAAAAAAAAAA
118 IA              B   AAAAAAAAAAAAAAAAAAAA
119 I             BBB     AAAAAAAAAAAAAAAAA
120 I            BBBBB      AAAAAAAAAAAAAA
121 I          BBBBBBB        AAAAAAAAAAA
122 I        BBBBBBBBB           AAAAAAA
123 I       BBBBBBBBBB             AAAA
124 I     BBBBBBBBBBBBB              A
125 I   BBBBBBBBBBBBBBB
126 I  BBBBBBBBBBBBBBBB
127 IBBBBBBBBBBBBBBBBBB
128 IBBBBBBBBBBBBBBBBBBB
129 IBBBBBBBBBBBBBBBBBBB
130 IBBBBBBBBBBBBBBBBBBB
131 IBBBBBBBBBBBBBBBBBBBB
132 IBBBBBBBBBBBBBBBBBBBBB
133 IBBBBBBBBBBBBBBBBBBBBBBB
134 IBBBBBBBBBBBBBBBBBBBBBBBB
135 IBBBBBBBBBBBBBBBBBBBBBBBBB
```

```
 ENTER ONE OF THE FOLLOWING OPTIONS:
FILEGEN    MAPGEN    CNCALC    TTY    STOP
STOP
 STOP

NORMAL EXIT.  EXECUTION TIME:        1329 MILLISECONDS.
```

```
@ASG,A SOILFILE.
READY
@ASG,A AREABND.
READY
@ASG,A LANDFILE.
READY
@ASG,UP AREAFILE.
READY
@USE 10,SOILFILE.
READY
@USE 12,AREABND.
READY
@USE 14,LANDFILE.
READY
@USE 11,AREAFILE.
READY
@XQT LIB.CNPROG

  * CNPROG *  AN EASY-TO-USE SYSTEM FOR COMPUTING
  * CNPROG *   RUNOFF CURVE NUMBERS
  * CNPROG *   CONVERTS SPATIAL SOILS AND WATERSHED BOUNDS TO
  * CNPROG *   DIGITAL FORM FOR USE WITH DIGITAL LAND USE DATA

  ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN    MAPGEN    CNCALC    TTY    STOP
TTY
 TTY

  * CNPROG *  TELETYPE OPTION SELECTED

  ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN    MAPGEN    CNCALC    TTY    STOP
FILEGEN
 FILEGEN

  * CNPROG *  BOUNDARY FILE PROCESSOR:
 ENTER H FOR LIST OF OPTIONS

  ENTER BNDFIL OPTION:
H

  BNDFIL OPTIONS:
 H   STOP    GO     INFILE    SHIFT
 OUTFILE    SOILS    DIGITIZER    FORMAT

  ENTER BNDFIL OPTION:
INFILE

  ENTER BOUNDARY INPUT FILE UNIT IN COLS. 1-2
12

  ENTER BNDFIL OPTION:
OUTFILE
```

```
 ENTER SCAN LINE FILE OUTPUT UNIT IN COLS. 1-2
11

 ENTER BNDFIL OPTION:
FORMAT

 ENTER BOUNDFIL FORMAT
(3I5)

 ENTER BNDFIL OPTION:
GO

 INPUT BOUNDARY POINT FILE = UNIT 12
 OUTPUT SCAN LINE FILE= UNIT 11

 BOUNDARY FILE FORMAT=(3I5)

 INDEX    SUBAREA NUMBER
    1              1
    2              2
    3              3
    4              4
    5              5

 SUBAREA POINT FILE CONTAINS    183 RECORDS

 * CNPROG *  NUMBER OF RECORDS TO SORT=   183

 SORT COMPLETED

 * CNPROG *   FILEGEN OPTIONS:
 LFBNDS    GO    STOP

 ENTER FILEGEN OPTION:
LFBNDS

 ENTER LAND COVER FILE LINEST(COL. 1-5) AND LINEND(COL. 6-10)
 100  135

 ENTER NUMBER OF STRIPS IN LAND COVER FILE(COL. 1)
2

 ENTER FIRST ELEMENT FOR STRIP 1(COL.1-5):
 1500

 ENTER FIRST ELEMENT FOR STRIP 2(COL.1-5):
 1530

 ENTER LAST ELEMENT FOR STRIP 2(COL.1-5):
 1570

 ENTER FILEGEN OPTION:
GO
```

```
 OUTPUT FILE UNIT= 11

  LAND COVER FILE DATA:
 NSTRIP=  2
 LINEST=   100
 LINEND=   135

    STRIP     1ST ELEMENT     LAST ELEMENT
      1          1500            1529
      2          1530            1570

  * CNPROG *   AREAS    2 AND    3 OVERLAP AT COLUMN  1537 LINE   105

  * CNPROG *   AREAS    2 AND    3 OVERLAP AT COLUMN  1537 LINE   106

  * CNPROG *   AREAS    2 AND    3 OVERLAP AT COLUMN  1537 LINE   107

  * CNPROG *   AREAS    2 AND    3 OVERLAP AT COLUMN  1536 LINE   110


  * CNPROG *   AREAS    2 AND    3 OVERLAP AT COLUMN  1536 LINE   111

  * CNPROG *   SCAN LINE FILE IS WRITTEN

  ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN    MAPGEN    CNCALC    TTY    STOP
MAPGEN
 MAPGEN

  * CNPROG *   MAPGEN OPTION
 ENTER ONE OF THE FOLLOWING OPTIONS
 INFILE    PRINTFILE    GO    STOP
INFILE

  ENTER INPUT FILE UNIT IN COL. 1-2:
11

  * CNPROG *   MAPGEN OPTION
 ENTER ONE OF THE FOLLOWING OPTIONS
 INFILE    PRINTFILE    GO    STOP
GO



 INPUT FILE UNIT= 11
 PRINT FILE UNIT=  6



 SUBAREA FILE CONTAINS  2 STRIPS
 1ST LINE= 100      LAST LINE= 135
```

```
INDEX     SUB-AREA NO.    MAP SYMBOL
  1            1              A
  2            2              B
  3            3              C
  4            4              D
  5            5              E
SUB-AREA MAP STRIP NUMBER  1


 1500I1505I1510I1515I1520I1525I1530I
     I    I    I    I    I    I    I
100 I
101 I
102 I
103 I
104 I
105 I
106 I        A                    B
107 I        AAAA          BBBBBBBB
108 I       AAAAAAABBBBBBBBBBBBBBBB
109 I       AAAAAAABBBBBBBBBBBBBBBB
110 I       AAAAAAABBBBBBBBBBBBBBBB
111 I      AAAAAAAABBBBBBBBBBBBBBBB
112 I      AAAAAAAABBBBBBBBBBBBBBBB
113 I      AAAAAAAABBBBBBBBBBBBBBBB
114 I     AAAAAAAAABBBBBBBBBBBBBBBB
115 I     AAAAAAAAABBBBBBBBBBBBBBBB
116 I     AAAAAAAAABBBBBBBBBBBBBB D
117 I     AAAAAAAAABBBBBBBBBBBBDDDD
118 I    AAAAAAAAAABBBBBBBBB DDDDDD
119 I    AAAAAAAAAABBBBBB DDDDDDDDD
120 I    AAAAAAAAAABBBB DDDDDDDDDDD
121 I   AAAAAAAAAAAB DDDDDDDDDDDDDD
122 I   AAAAAAAAAAADDDDDDDDDDDDDDDD
123 I   AAAAAAAAAAA      DDDDDDDDDD
124 I  AAAAAAAAAAAAAAAAAAAA    DDDD
125 I  AAAAAAAAAAAAAAAAAAAAAAAAAAAA
126 I       AAAAAAAAAAAAAAAAAAAAAAA
127 I             AAAAAAAAAAAAAAAAA
128 I                  AAAAAAAAAAAA
129 I                        AAAAAA
130 I                             A
131 I
132 I
133 I
134 I
135 I
```

```
SUB-AREA MAP STRIP NUMBER  2

     1530I1535I1540I1545I1550I1555I1560I1565I1570I
         I    I    I    I    I    I    I    I    I
    100 I
    101 I                CCCCCCC
    102 I            CCCCCCCCCC
    103 I        CCCCCCCCCCCCC
    104 I        CCCCCCCCCCCC
    105 I       CCCCCCCCCCCCCDDDDDDDDDDD
    106 IBBBBBBBCCCCCCCCCCCCCDDDDDDDDDDDD
    107 IBBBBBBBCCCCCCCCCCCCCDDDDDDDDDDDD
    108 IBBBBBBBCCCCCCCCCCCCCDDDDDDDDDDDDD
    109 IBBBBBBBCCCCCCCCCCCCCDDDDDDDDDDDDD
    110 IBBBBBBCCCCCCCCCCCCCCDDDDDDDDDDDDDD
    111 IBBBBBBCCCCCCCC DDDDDDDDDDDDDDDDDDD
    112 IBBBBBBC    DDDDDDDDDDDDDDDDDDDDDDDD
    113 IBBBBBBDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    114 IBBB DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    115 IBDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    116 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    117 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    118 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    119 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    120 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    121 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
    122 IDDDDDDDDDDDDDDDDDDDDDDDDDDD
    123 IDDDDDDDDDDDDDDDDDDDDDDDDD
    124 IDDDDDDDDDDDDDDDDDDDDDDD
    125 IE DDDDDDDDDDDDDDDDDDDD
    126 IEEEEE   DDDDDDDDDDDD
    127 IEEEEEEEEE DDDDDDDD
    128 IEEEEEEEEEEE DDDDD
    129 IEEEEEEEEEEEEE D
    130 IEEEEEEEEEEEEEEE
    131 IEEEEEEEEEEEEE
    132 I    EEEEEEE
    133 I        E
    134 I
    135 I

 ENTER ONE OF THE FOLLOWING OPTIONS:
 FILEGEN     MAPGEN     CNCALC     TTY     STOP
CNCALC
 CNCALC

  * CNPROG * CNCALC OPTION:
 ENTER H FOR LIST OF CNCALC OPTIONS
 ENTER CNCALC OPTION:
H

  * CNPROG *   LIST OF CNCALC OPTIONS:
 FORMAT    SOILFILE    SOILTABLE     CNTABLE
  LANDFILE    AREAFILE    GO    H    STOP
```

```
 ENTER CNCALC OPTION:
FORMAT

  ENTER FORMAT:
(I5,2X,50A1)
 ENTER CNCALC OPTION:
SOILFILE

  ENTER SOIL FILE UNIT IN COL. 1-2
10
 ENTER CNCALC OPTION:
LANDFILE

  ENTER LAND COVER FILE UNIT IN COL. 1-2:
14
 ENTER CNCALC OPTION:
AREAFILE

  ENTER SUB-AREA FILE UNIT IN COL. 1-2
11
 ENTER CNCALC OPTION:
CNTABLE

  ENTER TABLE OF VALUES FOR LAND USE SYMBOL(COL. 1),
 CN FOR SOIL TYPES A(COL. 2-5), B(COL. 6-10), C(COL. 11-15),
 AND D(COL. 16-20)
*  25   55   70   77
.  36   60   73   78
O  90   93   94   94
+  60   74   83   87

 ENTER CNCALC OPTION:
GO

  CNCALC FILE DATA:
 LAND USE FILE UNIT= 14      SUB-AREA FILE UNIT= 11
  SOIL SCAN LINE FILE UNIT= 10

   LAND COVER FILE FORMAT=(I5,2X,50A1)

     CN - LAND USE - SOIL TABLE:
 SYMBOL     A    B    C    D
    *      25.0 55.0 70.0 77.0
    .      36.0 60.0 73.0 78.0
    O      90.0 93.0 94.0 94.0
    +      60.0 74.0 83.0 87.0

  SUB-AREA FILE INDEX VALUES:

  INDEX    SUB-AREA NO.
   1            1
   2            2
   3            3
   4            4
   5            5
```

```
 SUB-AREA FILE BOUNDS:
FIRST LINE=   100      LAST LINE=   135

 ELEMENT LIMITS:
STRIP     1ST ELEMENT     LAST ELEMENT
  1           1500             1529
  2           1530             1570

 BACKGROUND SOIL TYPE IS D

 CN SUMMARY TABLE:
INDEX    SUB-AREA     TOT. PIXELS    CLASSIFIED PIXELS    CN
   1         1            256.                256.        80.
   2         2            239.                239.        71.
   3         3            130.                130.        26.
   4         4            607.                607.        65.
   5         5             75.                 75.        65.

  TOTALS:                1307.               1307.        65.

        SUB-AREA - SOIL PERCENT TABLE:
SUB-AREA        A        B        C       D
    1          .00     2.34      .00    97.66
    2        33.47      .00      .00    66.53
    3       100.00      .00      .00      .00
    4        47.94    14.33      .00    37.73
    5          .00    96.00      .00     4.00

 TOTALS:     38.33    12.62      .00    49.04



LAND COVER PERCENTAGE TABLE:

             LAND COVER SYMBOL
SUB-AREA     *      .      O      +
      1      .00  76.56   4.69  18.75
      2    30.54  24.69  11.72  33.05
      3    93.08   6.15    .00    .77
      4    12.36  27.02  29.98  30.64
      5      .00  65.33   1.33  33.33

  TOTALS:  20.58  36.42  17.06  25.94

 END OF CNCALC ROUTINE

 ENTER ONE OF THE FOLLOWING OPTIONS:
FILEGEN    MAPGEN    CNCALC    TTY    STOP
CNCALC
 CNCALC

  * CNPROG * CNCALC OPTION:
 ENTER H FOR LIST OF CNCALC OPTIONS
 ENTER CNCALC OPTION:
H
```

```
 * CNPROG *   LIST OF CNCALC OPTIONS:
FORMAT    SOILFILE    SOILTABLE    CNTABLE
 LANDFILE    AREAFILE    GO    H    STOP
ENTER CNCALC OPTION:
FORMAT

 ENTER FORMAT:
(I5,2X,50A1)
ENTER CNCALC OPTION:
SOILFILE

 ENTER SOIL FILE UNIT IN COL. 1-2
10
ENTER CNCALC OPTION:
SOILTABLE

 ENTER SOIL FILE TABLE UNIT IN COL. 1-2:
 5

 ENTER SUB-AREA - SOIL PERCENT TABLE:
   1  0.0 2.34  0.097.66
   233.47  0.0  0.066.53
   3 100.  0.0  0.0  0.0
   4 <
   447.94/4.33<
   447.9414.3 0.0  37.7<
   447.9414.33  0.0 4.0
   5  0.0  96.  0.0  4.0

ENTER CNCALC OPTION:
SOILTABLE

 ENTER SOIL FILE TABLE UNIT IN COL. 1-2:
 5

 ENTER SUB-AREA - SOIL PERCENT TABLE:
   1  0.02.34  0.097.66
   233.47  0.0  0.066.53
   3 100.  0.0  0.0  0.0
   447.9414.33  0.037.73
   5  0.0  96.  0.0  4.0

ENTER CNCALC OPTION:
LANDFILE

 ENTER LAND COVER FILE UNIT IN COL. 1-2:
14
ENTER CNCALC OPTION:
AREAFILE

 ENTER SUB-AREA FILE UNIT IN COL. 1-2
11
ENTER CNCALC OPTION:
GO
```

CNCALC FILE DATA:
LAND USE FILE UNIT= 14   SUB-AREA FILE UNIT= 11
SOIL TABLE FILE UNIT= 5

LAND COVER FILE FORMAT=(I5,2X,50A1)

CN - LAND USE - SOIL TABLE:

SYMBOL	A	B	C	D
*	25.0	55.0	70.0	77.0
.	36.0	60.0	73.0	78.0
0	90.0	93.0	94.0	94.0
+	60.0	74.0	83.0	87.0

SUB-AREA - SOIL PERCENT TABLE:

SUB-AREA	A	B	C	D
1	.00	2.34	.00	97.66
2	33.47	.00	.00	66.53
3	100.00	.00	.00	.00
4	47.94	14.33	.00	37.73
5	.00	96.00	.00	4.00

SUB-AREA FILE INDEX VALUES:

INDEX	SUB-AREA NO.
1	1
2	2
3	3
4	4
5	5

SUB-AREA FILE BOUNDS:
FIRST LINE= 100   LAST LINE= 135

ELEMENT LIMITS:

STRIP	1ST ELEMENT	LAST ELEMENT
1	1500	1529
2	1530	1570

CN SUMMARY TABLE:

INDEX	SUB-AREA	TOT. PIXELS	CLASSIFIED PIXELS	CN
1	1	256.	256.	80.
2	2	239.	239.	71.
3	3	130.	130.	26.
4	4	607.	607.	71.
5	5	75.	75.	66.
TOTALS:		1307.	1307.	68.

```
LAND COVER PERCENTAGE TABLE:

              LAND COVER SYMBOL
SUB-AREA        *     .     O     +
     1        .00 76.56  4.69 18.75
     2      30.54 24.69 11.72 33.05
     3      93.08  6.15   .00   .77
     4      12.36 27.02 29.98 30.64
     5        .00 65.33  1.33 33.33

  TOTALS: 20.58 36.42 17.06 25.94

 END OF CNCALC ROUTINE

 ENTER ONE OF THE FOLLOWING OPTIONS:
FILEGEN   MAPGEN    CNCALC    TTY    STOP
STOP
 STOP

NORMAL EXIT. EXECUTION TIME:         7169 MILLISECONDS.
```

APPENDIX B

OUTPUT FOR EXAMPLE RUN 4

```
 * CNPROG *    AN EASY-TO-USE SYSTEM FOR COMPUTING
 * CNPROG *    RUNOFF CURVE NUMBERS
 * CNPROG *    CONVERTS SPATIAL SOILS AND WATERSHED BOUNDS TO
 * CNPROG *    DIGITAL FORM FOR USE WITH DIGITAL LAND USE DATA

 ENTER ONE OF THE FOLLOWING OPTIONS.
FILEGEN     MAPGEN     CNCALC     TTY     STOP
FILEGEN

 * CNPROG *  BOUNDARY FILE PROCESSOR

 INPUT BOUNDARY POINT FILE = UNIT 13
 OUTPUT SCAN LINE FILE= UNIT 10

 BOUNDARY FILE FORMAT=(3I5)

 BACKGROUND SOIL TYPE= D

 INDEX      SUBAREA NUMBER
   1              1
   1              1
   2              2

 SOIL POINT FILE CONTAINS     104 RECORDS

 * CNPROG *  NUMBER OF RECORDS TO SORT=    104

 SORT COMPLETED

 * CNPROG *  FILEGEN PHASE II PROCESSOR

OUTPUT FILE UNIT= 10

 LAND COVER FILE DATA.
NSTRIP=  2
LINEST=    100
LINEND=    135

   STRIP     1ST ELEMENT     LAST ELEMENT
     1          1500             1529
     2          1530             1570

 * CNPROG *  SCAN LINE FILE IS WRITTEN

 ENTER ONE OF THE FOLLOWING OPTIONS.
FILEGEN     MAPGEN     CNCALC     TTY     STOP
FILEGEN

 * CNPROG *  BOUNDARY FILE PROCESSOR

 INPUT BOUNDARY POINT FILE = UNIT 12
 OUTPUT SCAN LINE FILE= UNIT 11

 BOUNDARY FILE FORMAT=(3I5)

 INDEX      SUBAREA NUMBER
   1              1
   2              2
```

```
   5              5

 SUBAREA POINT FILE CONTAINS    183 RECORDS

 * CNPROG *  NUMBER OF RECORDS TO SORT=   183

 SORT COMPLETED

 * CNPROG *  FILEGEN PHASE II PROCESSOR



OUTPUT FILE UNIT= 11

 LAND COVER FILE DATA.
NSTRIP=  2
LINEST=   100
LINEND=   135

   STRIP    1ST ELEMENT    LAST ELEMENT
     1         1500           1529
     2         1530           1570

 * CNPROG *  AREAS    2 AND    3 OVERLAP AT COLUMN  1537 LINE   105

 * CNPROG *  AREAS    2 AND    3 OVERLAP AT COLUMN  1537 LINE   106

 * CNPROG *  AREAS    2 AND    3 OVERLAP AT COLUMN  1537 LINE   107

 * CNPROG *  AREAS    2 AND    3 OVERLAP AT COLUMN  1536 LINE   110

 * CNPROG *  AREAS    2 AND    3 OVERLAP AT COLUMN  1536 LINE   111

 * CNPROG *  SCAN LINE FILE IS WRITTEN

 ENTER ONE OF THE FOLLOWING OPTIONS.
FILEGEN    MAPGEN    CNCALC    TTY    STOP
MAPGEN

 * CNPROG *  MAPGEN PROCESSOR


INPUT FILE UNIT= 10
PRINT FILE UNIT=  6


  SOILS FILE CONTAINS  2 STRIPS
1ST LINE=   100     LAST LINE=   135
 BACKGROUND SOIL TYPE IS D
```

```
 1500I1505I1510I1515I1520I1525I1530I
     I    I    I    I    I    I    I
100 I        AAAAAAAAAAAAAAAAAAAAAA
101 I        AAAAAAAAAAAAAAAAAAAAAA
102 I        AAAAAAAAAAAAAAAAAAAAAA
103 I        AAAAAAAAAAAAAAAAAAAAAA
104 I        AAAAAAAAAAAAAAAAAAAAAA
105 I           AAAAAAAAAAAAAAAAAAA
106 I             AAAAAAAAAAAAAAAAA
107 I                AAAAAAAAAAAAAA
108 I                   AAAAAAAAAAA
109 I                      AAAAAAAA
110 I                        AAAAAA
111 I                           AAA
112 I
113 I                      AAAAAAAA
114 I                     AAAAAAAAA
115 I                   AAAAAAAAAA
116 I                  AAAAAAAAAA
117 I                    AAAAAAAA
118 I                     AAAAAA
119 I                       AAA
120 I                        A
121 I
122 I
123 I
124 I
125 I
126 I
127 I
128 I                            BB
129 I                           BBB
130 I                         BBBBB
131 I                       BBBBBBB
132 I                      BBBBBBBB
133 I                    BBBBBBBBBB
134 I                   BBBBBBBBBBB
135 I                  BBBBBBBBBBBB
```

```
 1530I1535I1540I1545I1550I1555I1560I1565I1570I
     I    I    I    I    I    I    I    I    I
100 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
101 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
102 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
103 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
104 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
105 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
106 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
107 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
108 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
109 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
110 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
111 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
112 IAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
113 IA AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
114 I     AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
115 I        AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
116 I          AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
117 I             AAAAAAAAAAAAAAAAAAAAAAAAAAAA
118 I               BAAAAAAAAAAAAAAAAAAAAAAAA
119 I             BBB   AAAAAAAAAAAAAAAAAAAA
120 I            BBBBB     AAAAAAAAAAAAAAAA
121 I          BBBBBBB       AAAAAAAAAAAA
122 I        BBBBBBBBB          AAAAAAAA
123 I       BBBBBBBBBB             AAAAA
124 I     BBBBBBBBBBBBBB              A
125 I   BBBBBBBBBBBBBBBB
126 I  BBBBBBBBBBBBBBBBB
127 IBBBBBBBBBBBBBBBBBBB
128 IBBBBBBBBBBBBBBBBBBBB
129 IBBBBBBBBBBBBBBBBBBBB
130 IBBBBBBBBBBBBBBBBBBBB
131 IBBBBBBBBBBBBBBBBBBBBB
132 IBBBBBBBBBBBBBBBBBBBBBB
133 IBBBBBBBBBBBBBBBBBBBBBBBB
134 IBBBBBBBBBBBBBBBBBBBBBBBBB
135 IBBBBBBBBBBBBBBBBBBBBBBBBBB
```

```
 ENTER ONE OF THE FCLLOWING OPTIONS.
FILEGEN    MAPGEN    CNCALC    TTY    STOP
MAPGEN

 * CNPROG *  MAPGEN PROCESSOR


INPUT FILE UNIT= 11
PRINT FILE UNIT=  6



SUBAREA FILE CONTAINS  2 STRIPS
1ST LINE=  100     LAST LINE=  135


 INDEX      SUB-AREA NO.     MAP SYMBOL
   1             1               A
   2             2               B
   3             3               C
```

SUB-AREA MAP STRIP NUMBER 1

```
   1500I1505I1510I1515I1520I1525I1530I
         I    I    I    I    I    I    I
100 I
101 I
102 I
103 I
104 I
105 I
106 I        A                    B
107 I        AAAA          BBBBBBBB
108 I       AAAAAAABBBBBBBBBBBBBBBB
109 I       AAAAAAABBBBBBBBBBBBBBBB
110 I       AAAAAAABBBBBBBBBBBBBBBB
111 I      AAAAAAAABBBBBBBBBBBBBBBB
112 I      AAAAAAAABBBBBBBBBBBBBBBB
113 I      AAAAAAAABBBBBBBBBBBBBBBB
114 I     AAAAAAAAABBBBBBBBBBBBBBBB
115 I     AAAAAAAAABBBBBBBBBBBBBBBB
116 I     AAAAAAAAABBBBBBBBBBBBBB D
117 I     AAAAAAAAABBBBBBBBBBBBDDDD
118 I    AAAAAAAAAABBBBBBBBB DDDDDD
119 I    AAAAAAAAAABBBBBB DDDDDDDDD
120 I    AAAAAAAAAABBBB DDDDDDDDDDD
121 I   AAAAAAAAAAAB DDDDDDDDDDDDDD
122 I   AAAAAAAAAAADDDDDDDDDDDDDDDD
123 I   AAAAAAAAAAA      DDDDDDDDDD
124 I  AAAAAAAAAAAAAAAAAAAA    DDDD
125 I  AAAAAAAAAAAAAAAAAAAAAAAAAAAA
126 I       AAAAAAAAAAAAAAAAAAAAAAA
127 I             AAAAAAAAAAAAAAAAA
128 I                  AAAAAAAAAAAA
129 I                        AAAAAA
130 I                             A
131 I
132 I
133 I
134 I
135 I
```

```
 1530I1535I1540I1545I1550I1555I1560I1565I1570I
     I    I    I    I    I    I    I    I    I
100 I
101 I                CCCCCCC
102 I            CCCCCCCCCC
103 I        CCCCCCCCCCCCC
104 I        CCCCCCCCCCCC
105 I       CCCCCCCCCCCCCDDDDDDDDDDD
106 IBBBBBBBCCCCCCCCCCCCCCDDDDDDDDDDDD
107 IBBBBBBBCCCCCCCCCCCCCCDDDDDDDDDDDD
108 IBBBBBBBCCCCCCCCCCCCCCDDDDDDDDDDDDD
109 IBBBBBBBCCCCCCCCCCCCCCDDDDDDDDDDDDD
110 IBBBBBBCCCCCCCCCCCCCCCDDDDDDDDDDDDDD
111 IBBBBBBCCCCCCCC DDDDDDDDDDDDDDDDDDDD
112 IBBBBBBC    DDDDDDDDDDDDDDDDDDDDDDDD
113 IBBBBBBDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
114 IBBB DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
115 IBDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
116 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
117 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
118 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
119 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
120 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
121 IDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
122 IDDDDDDDDDDDDDDDDDDDDDDDDDDDD
123 IDDDDDDDDDDDDDDDDDDDDDDDDDD
124 IDDDDDDDDDDDDDDDDDDDDDDDD
125 IE DDDDDDDDDDDDDDDDDDDDD
126 IEEEEE   DDDDDDDDDDDD
127 IEEEEEEEEE DDDDDDDD
128 IEEEEEEEEEEE DDDDD
129 IEEEEEEEEEEEEE D
130 IEEEEEEEEEEEEEEE
131 IEEEEEEEEEEEEE
132 I    EEEEEEE
133 I        E
134 I
135 I

 ENTER ONE OF THE FOLLOWING OPTIONS.
FILEGEN    MAPGEN    CNCALC    TTY    STOP
CNCALC

 * CNPROG * CNCALC PROCESSOR
FORMAT
SOILFILE
LANDFILE
AREAFILE
CNTABLE
GO

 CNCALC FILE DATA.
SUB-AREA FILE UNIT= 11
LAND USE FILE UNITS= 14 14 14 14 14 14 14
 SOIL SCAN LINE FILE UNIT= 10

  LAND COVER FILE FORMAT=(I5,2X,50A1)

   CN - LAND USE - SOIL TABLE.
SYMBOL     A     B     C     D
   *      25.0  55.0  70.0  77.0
   .      36.0  60.0  73.0  78.0
```

INDEX	SUB-AREA NO.
1	1
2	2
3	3
4	4
5	5

SUB-AREA FILE BOUNDS.
FIRST LINE= 100 LAST LINE= 135

ELEMENT LIMITS.

STRIP	1ST ELEMENT	LAST ELEMENT
1	1500	1529
2	1530	1570

BACKGROUND SOIL TYPE IS D

CN SUMMARY TABLE.

INDEX	SUB-AREA	TOT. PIXELS	CLASSIFIED PIXELS	CN
1	1	256.	256.	80.
2	2	239.	239.	62.
3	3	130.	130.	26.
4	4	607.	607.	64.
5	5	75.	75.	65.
TOTALS.		1307.	1307.	63.

SUB-AREA - SOIL PERCENT TABLE.

SUB-AREA	A	B	C	D
1	0.0	2.34	0.0	97.66
2	55.65	0.0	0.0	44.35
3	100.00	0.0	0.0	0.0
4	50.91	14.33	0.0	34.76
5	0.0	96.00	0.0	4.00
TOTALS.	43.76	12.62	0.0	43.61

LAND COVER PERCENTAGE TABLE.

	LAND COVER SYMBOL			
SUB-AREA	*	.	O	+
1	0.0	76.56	4.69	18.75
2	30.54	24.69	11.72	33.05
3	93.08	6.15	0.0	0.77
4	12.36	27.02	28.17	32.45
5	0.0	65.33	1.33	33.33

```
 TOTALS. 20.58 36.42 16.22 26.78

END OF CNCALC ROUTINE

ENTER ONE OF THE FOLLOWING OPTIONS.
FILEGEN    MAPGEN    CNCALC    TTY    STOP
STOP
```

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CP-R1-04040		

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9. Performing Organization Name and Address USDA-SEA-AR Hydrology Laboratory Beltsville, Md. 20705	11. Contract or Grant No.
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12. Sponsoring Agency Name and Address USDA-SEA-AR Hydrology Laboratory Beltsville, Md. 20705	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Several investigations have shown the potential of using remotely sensed data in hydrologic modeling. One of the most promising is in the estimation of the land cover in the computation of the Soil Conservation Service Runoff Curve Number. Each of these studies have shown these data to be cost-effective.

This report describes a computer based procedure for estimating watershed Curve Numbers using remotely sensed data. It is a linkage of some previously developed package programs and new procedures that have been streamlined for this particular application. Landsat data are emphasized, however, other types of data could be used. Examples are presented on each aspect.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Hydrology Remote Sensing Curve Numbers	

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